THE EFFECT OF TIME UPON VARIABILITY

STANFORD UNIVERSITY LIBRARY
APR 1 1927

BY

ELLA WOODYARD

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

STANFORD UNIVERSITY LIBRARIES
WITHDRAWN

BUREAU OF PUBLICATIONS
Teachers College, Columbia University
NEW YORK CITY
1926

B781
C72W
UNCLASSED
Dissertation

THE EFFECT OF TIME UPON VARIABILITY

BY

ELLA WOODYARD

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

BUREAU OF PUBLICATIONS
Teachers College, Columbia University
NEW YORK CITY
1926

Copyright, 1926, by Teachers College, Columbia University

ACKNOWLEDGMENTS

Many of the data utilized in this study were collected by the Institute of Educational Research, Division of Educational Psychology, Teachers College, Columbia University, New York City. The Carnegie Foundation and the Commonwealth Fund have made subventions to the Institute to make such collections possible.

Under the auspices of the New York State Commission on Ventilation and financed by a gift from Mrs. Elizabeth Milbank Anderson, other data which have been discussed herein were collected by Dr. E. L. Thorndike, Dr. W. A. McCall, Dr. J. C. Chapman, and Mrs. Georgie J. Ruger.

The data on repeated tests with Army Alpha were collected by Dr. G. M. Ruch of the University of Iowa.

The data on the Thorndike Tests of Word Knowledge were collected by Dr. P. M. Symonds of Teachers College, Columbia University.

The tests, eighteen hours in duration, were given to twenty adults by Dr. J. S. Orleans.

Certain data herein utilized have been collected through the kindness of high school teachers in Kansas City, Denver, and other cities, and of normal school teachers in Trenton.

Principals and teachers of public schools have permitted tests to be given to their pupils, notably those of P. S. No. 6, P. S. No. 51, P. S. No. 43, and Speyer School, all in New York City.

To all of the organizations and individuals concerned in this work I am under obligations, and hereby express my thanks. Many hundreds of persons whose names I have not known have written the tests which I have used. They will never see this page. None the less, I am grateful to each of them for his co-operation and labor.

The committee of the Teachers College Faculty which has supervised this study is composed of Dr. A. I. Gates, Dr. W. A.

McCall, and Dr. T. H. Briggs. To each of them I offer my thanks for his counsel and consideration.

My largest debt of gratitude is to my chief, Dr. E. L. Thorndike, Director of the Institute of Educational Research, Division of Educational Psychology. Without his kindness, advice, and permission to use data accumulated in the office, this study could not have covered so wide a range. I offer him my thanks, my appreciation of his influence, and I pledge my loyalty to my work with him as my truest acknowledgment of the obligation I owe him.

E. W.

CONTENTS

CHAP.		PAGE
I.	The Problem: Summary of Conclusions	1
II.	The Problem	4
III.	The Data and Their Treatment	7
IV.	The Data and Their Treatment (*continued*)	22
V.	The Data and Their Treatment (*concluded*)	43
VI.	Discussion and Conclusions	52

Digitized by the Internet Archive
in 2025

https://archive.org/details/effectoftimeupon0000unse

THE EFFECT OF TIME UPON VARIABILITY

CHAPTER I

THE PROBLEM: SUMMARY OF CONCLUSIONS

The problem proposed for study herein is: In what degree is an individual variable in his performance of mental work when the time elapsing between work periods is a variable quantity ranging from a few minutes through a half day, a day, several days, a week, a month, a semester, to a year?

The method of the study is a comparison of the coefficients of correlation obtained in the following data:

1. Tests 2, 4, 5, 6, 7 of Army Alpha, Forms 6, 7, 8, 9, 5, administered, with time limits shortened one-half except in Test 2 which was cut from five to two minutes to insure work sufficient for the allotted period, on alternate days, Sundays excepted, until each form had been twice written. Two groups of college students studied; separate and average coefficients of inter-correlation reported. $N = 14$, $N = 16$.

2. Thorndike Intelligence Examination for High School Graduates. Normal school students tested for three hours one day with retest on another form of the same test one year later. Coefficients of inter-correlation reported. $N = 170$.

3. I. E. R.[1] Tests of Selective and Relational Thinking and of Generalization and Organization. Ninth grade students, fifteen years old, in senior high schools tested for two hours one day; retested in the tenth grade one year later. Two groups studied; average coefficients of inter-correlation reported. $N = 250$, $N = 250$.

4. Tests in Sentence Completion, Arithmetic, Thorndike Non-Verbal Intelligence Examination, Briggs Analogies, Burgess Reading, Thorndike Intelligence Examination for High School

[1] I.E.R. is a technical abbreviation for the Institute of Educational Research, Teachers College, Columbia University.

Graduates, etc. Adults of non-college grade tested for nine hours on one day; retested with other forms of the same material one week later. Coefficients of inter-correlation for various types of material reported. $N = 20$.

5. Thorndike Test of Word Knowledge. Grades 4, 5, 6, 7, 8 tested; retested ten days later. Four forms, A, B, C, D, used in rotation. Coefficients of inter-correlation upon comparable halves of the same test and of the retest for each grade and for entire range reported. $N = 35$, $N = 58$, $N = 166$, $N = 190$, $N = 219$. Total $N = 668$.

6. I. E. R.[1] Tests in Completion and Arithmetic. Grade 6 tested two hours in forenoon; retested on comparable material in the afternoon of the same day. Coefficients of inter-correlation reported. $N = 205$.

7. Tests in Arithmetic, Thorndike Visual Vocabulary, Reading, Trabue Completions, Association and Selection. Grade 7 tested the same day; retests one semester later (time interval 133 to 136 days). Also tests in Ruger Proverbs, Mixed Relations. Same grade 7 tested the same day, 20 days after the first battery; retests approximately three months later (time interval 101 days). Also tests in Visual Vocabulary, Spelling, Courtis Arithmetic, Woody Arithmetic. Same grade 7 tested during the fortnight following the second battery; retests approximately three months later (time interval 100 to 103 days). Coefficients of inter-correlation on all groups of data reported. $N = 50$.

8. Tests in Handwriting. Grade 7 (same individuals as in *7* above) tested forenoon and afternoon on four different days with intervals of 17 days, 14 days, and 67 days. Also tested once on each of two days, 2 and 11 days after the second day's double testing. Coefficients of inter-correlation reported with averages for same day and longer intervals. $N = 50$.

9. Tests in Color Naming. College students tested twice in succession, again twice later in the same four-hour work period for five successive days. Coefficients of inter-correlation reported; also averages for each division of the early and late trials for time intervals of 0, 1, 2, 3, 4 days. $N = 19$.

10. Tests in Cancellation of 2's and 3's. College students (same individuals as in *9* above) tested in cancelling 2's and in cancelling 3's, twice during the same four-hour work period for 5 successive

days. Coefficients of inter-correlation reported, also averages for cancelling 2's and cancelling 3's for time intervals of 0, 1, 2, 3, 4 days. $N = 19$.

The most general conclusion from a review of the evidence is that the time factor is of small moment in causing an individual to vary in the mental work he produces under conditions found in the administration of such standard tests as are common in intelligence and educational testing. In practically all of the data examined, whatever correlation is obtained for the short time interval is changed by but a few points in the second decimal place when the time interval is increased.

CHAPTER II

THE PROBLEM

In presenting figures to express the measurement of quantities in the physical sciences, it has ordinarily been assumed that the figures are accurate measures of the quantity in question under specified conditions of temperature, altitude, atmospheric condition, and the like, except as they are impaired by errors in the experimenter's management of his tools. In presenting figures as expressing the measurement of living beings, it has been assumed that, in addition to such errors of measurement, there are also inaccuracies due to inherent fluctuations in the individuals being measured. In the measurement of the products of intellectual work the assumption has been predicated that the obtained figures represent only an approximation, more or less crude, to the true measurement of the ability or achievement of the subjects concerned.

Empirical and mathematical inquiry has resulted in the development of formulæ for predicting the true measurement of mental products from a small number of actual measurements.[1] In the derivation of such formulæ it is assumed that a true measurement would be the mean or median or mode of an infinite or at least very large number of separate measurements. Further, it has usually been held that an interval of time sufficient for emotional strains or for feelings of fatigue to be dissipated, or for lack of normality in performance to be righted, but not sufficient for appreciable mental growth to have taken place, should be permitted to elapse between the several measurements needed to obtain a true measure.

In determining a figure to represent the reliability of a testing instrument for use in mental measurements, two procedures have been followed: (1) to obtain a coefficient of correlation from halves of the performance during a single sitting, and (2) to obtain a coefficient of correlation between scores in two forms of the

[1] Spearman, C.: "Coefficient of Correlation calculated from Faulty Data," *Brit. Jour. Psych.*, 3; 271–95, Oct. 1910. Brown, W.: *Essentials of Mental Measurement*, p. 102, 1911. McCall, W. A.: *How to Measure in Education*, p. 397, 1922. Kelley, T. L.: *Statistical Method*, pp. 203 ff.

test, different from one another, but as nearly equivalent in difficulty as could be constructed, and procured with a time interval of a few days between the two administrations. The latter procedure has been thought to be the more trustworthy on the theory that eccentricities of performance of individuals would be operative upon two scores made during an entire single sitting, but not upon two scores obtained several days apart. Genuinely chance errors of measurement would be uncorrelated with each other in the two scores obtained either at a single sitting or at two sittings, but errors of measurement due to the failure of the individual to register his true performance would be highly correlated in scores secured from a single session but presumably uncorrelated in scores from sessions some days apart.

The present inquiry attempts by comparison of coefficients of correlation obtained from several kinds of test material, upon individuals varying in age and mental attainments and measured under dissimilar environmental conditions, to study the effect of the time element in causing an individual to be inconstant in his mental work. Its results should have a bearing upon the question of the determination of the reliability of a test instrument. They should in addition help to determine whether the fairly common feeling that large differences in achievement are to be expected in the same individual is justified by the facts.

The problem of individual unevenness of performance has already been studied somewhat. Symonds,[2] in a study made upon Hawaiian children, used magnitude of difference in score as a measure of variability. The tests used were Forms 1 and 2 of the National Intelligence Test, Scales A and B. His finding that is of concern here is: "Individuals who do extremely poorly on a certain test in relation to their true ability are quite as likely to do extremely well on another test immediately following as they are to do poorly again, and *vice versa*."

Stenquist [3] has pointed out that pupils receive considerably different ratings in various mental tests and proposes that they be measured a number of times to obtain a trustworthy estimate.

Hollingworth [4] studied the inconstancy of individuals by using

[2] Symonds, P. M.: "A Study of Extreme Cases of Unreliability," *Jour. Ed. Psych.*, 15: 99–106, Feb. 1924.
[3] Stenquist, J. L.: "Unreliability of Individual Scores in Mental Measurements," *Jour. Ed. Res.*, 4; 347–54, Dec., '21.
[4] Hollingworth, H. L.: "Correlations of Achievement Within an Individual," *Jour. Exp. Psych.*, 8: 190–208, June 1925.

coefficients of correlation for six kinds of work chiefly muscular—Tapping, Coordination, Steadiness, Substitution, Color Naming, Pulse Rate. One of his conclusions is that "notable variations in score are nevertheless found, which are symmetrically distributed about their central tendency."

Thorndike [5] has shown by use of arrays in a correlation table as well as by scores in repeated tasks that the amount of variability to be expected when tests are retaken is about equal for various levels of ability, and is symmetrically distributed about the mean ability.

So far as the present study is concerned, the problem of variability of an individual is considered only in that phase which deals with the amount of variability due to a lapse of time of greater or less duration between testing experiences.

[5] Thorndike, E. L.: "The Variability of an Individual in Repetitions of the Same Task," *Jour. Exp. Psych.*, 6: 161–67, April 1923.
Thorndike, E. L.: *The Measurement of Intelligence.* (Now in press).

CHAPTER III

THE DATA AND THEIR TREATMENT

Professor Ruch of the University of Iowa,[1] repeated applications of Tests 2, 4, 5, 6, and 7 of the Army Alpha Intelligence Examination, using Forms 6, 7, 8, 9, and 5 in rotation, upon two groups of students, one in Leland Stanford University, the other in Iowa. The number of cases was 14 for one and 16 for the other. These tests were given with the time limit prescribed by the Army manual reduced by half except in Test 2 where the regulation five minutes was shortened to two minutes. This decreased time allowance made it certain that in all but a very few cases ample material was provided for the subjects to work upon. The tests were written upon alternate days, Sundays being excepted, so that the second trial for Form 5 occurred three weeks after the day of the first trial with Form 6, and 12 days after the first trial upon the identical material. Table I shows the coefficient of self-correlation of each form. In this and in all other tables presented in this study the unreliability is stated in terms of the Probable Error.

TABLE I

COEFFICIENT OF SELF-CORRELATION OF VARIOUS FORMS OF ARMY ALPHA[2]

Form	r $n=14$	r $n=16$	r Av.	Time Interval
6 *vs.* 6	.93 ± .03	.96 ± .02	.95	11 days
7 *vs.* 7	.96 ± .02	.94 ± .03	.95	12 "
8 *vs.* 8	.91 ± .03	.86 ± .05	.89	12 "
9 *vs.* 9	.91 ± .03	.91 ± .04	.91	11 "
5 *vs.* 5	.88 ± .04	.94 ± .03	.91	12 "

The fact that there is a difference in the rank order of the close-

[1] Ruch, G. M.: Correlations of Initial and Final Capacities in Learning'" *Jour. Exp. Psych.*, 6: 344–56, Oct., 1923.

[2] No other experimenter, so far as is known to the has writer, reported coefficients of self-correlation upon Tests 2, 4, 5, 6, and 7 of Army Alpha, written with shortened time schedule. The results here reported may be considered in comparison with figures reported in the *Memoirs of the National Academy of Sciences*, Vol. 15, pp. 417, 420. With full and double time limits, the coefficient of correlation on Alpha (form not specified) for 510 cases is there reported to be .967; for Test 2, .937; for Test 4, .940; for Test 5, .902; for Test 6, .960; for Test 7, .920; average coefficient of correlation for Tests 2, 4, 5, 6, and 7 is .932. For the five tests together the coefficient would doubtless be higher than .93 and less than .97. In the administration of the test the subjects were interrupted to make a mark on the paper at the point reached at the expiration of the usual time allowance, and then told to continue until time was called. The fact that the score for double time is thus partly made from the score for single time instead of being a bona fide second score, should be weighed in comparing this coefficient of correlation figure with those reported in this study.

ness of correspondence between the trials of the same form by the two groups is probably explained by the smallness of the populations involved.

Table II gives the coefficient of correlation of each trial of each form with each trial of every other form.

TABLE II

COEFFICIENTS OF INTER-CORRELATION OF VARIOUS FORMS OF ARMY ALPHA

14 STANFORD UNIVERSITY STUDENTS — 16 IOWA UNIVERSITY STUDENTS

Form 6 Day 1 / Form 6 Day 6

Form	Day	Stanford	Iowa	Av.	Stanford	Iowa	Av.
6	1				.93 ± .03	.96 ± .02	.95
7	2	.93 ± .03	.90 ± .04	.92	.97 ± .02	.95 ± .03	.96
8	3	.93 ± .03	.81 ± .07	.87	.83 ± .06	.83 ± .06	.83
9	4	.91 ± .04	.91 ± .04	.91	.92 ± .03	.82 ± .06	.87
5	5	.90 ± .04	.91 ± .04	.91	.93 ± .03	.97 ± .01	.95
6	6	.93 ± .03	.96 ± .02	.95			
7	7	.91 ± .04	.85 ± .06	.88	.96 ± .02	.81 ± .07	.89
8	8	.87 ± .05	.88 ± .05	.88	.89 ± .04	.81 ± .07	.85
9	9	.87 ± .05	.83 ± .06	.85	.93 ± .03	.80 ± .07	.87
5	10	.92 ± .03	.81 ± .07	.87	.91 ± .04	.91 ± .04	.91

Form 7 Day 2 / Form 7 Day 7

Form	Day	Stanford	Iowa	Av.	Stanford	Iowa	Av.
6	1	.93 ± .03	.90 ± .04	.92	.91 ± .04	.85 ± .06	.88
7	2				.96 ± .02	.94 ± .03	.95
8	3	.96 ± .02	.85 ± .06	.91	.96 ± .02	.87 ± .05	.92
9	4	.92 ± .04	.93 ± .03	.93	.94 ± .03	.90 ± .04	.92
5	5	.90 ± .04	.94 ± .03	.92	.96 ± .02	.93 ± .03	.95
6	6	.97 ± .02	.95 ± .03	.96	.96 ± .02	.81 ± .07	.89
7	7	.96 ± .02	.94 ± .03	.95			
8	8	.85 ± .06	.89 ± .04	.87	.93 ± .03	.93 ± .03	.93
9	9	.87 ± .05	.88 ± .05	.88	.95 ± .02	.89 ± .04	.92
5	10	.93 ± .03	.91 ± .04	.92	.92 ± .03	.95 ± .03	.94

Form 8 Day 3 / Form 8 Day 8

Form	Day	Stanford	Iowa	Av.	Stanford	Iowa	Av.
6	1	.93 ± .03	.81 ± .07	.87	.87 ± .05	.88 ± .05	.88
7	2	.96 ± .02	.85 ± .06	.91	.85 ± .06	.89 ± .04	.87
8	3				.91 ± .04	.86 ± .06	.89
9	4	.96 ± .02	.87 ± .05	.92	.96 ± .02	.93 ± .03	.95
5	5	.94 ± .03	.87 ± .05	.91	.91 ± .03	.97 ± .01	.94
6	6	.83 ± .06	.83 ± .06	.83	.89 ± .04	.81 ± .07	.85
7	7	.96 ± .02	.87 ± .05	.92	.93 ± .03	.93 ± .03	.93
8	8	.91 ± .04	.86 ± .06	.89			
9	9	.88 ± .05	.83 ± .06	.86	.94 ± .03	.94 ± .03	.94
5	10	.90 ± .04	.80 ± .07	.85	.94 ± .03	.95 ± .02	.95

TABLE II (*Continued*)

Form	Day	Form 9 Day 4 Stanford	Iowa	Av.	Form 9 Day 9 Stanford	Iowa	Av.
6	1	.91 ± .04	.91 ± .04	.91	.87 ± .05	.83 ± .06	.85
7	2	.92 ± .04	.93 ± .03	.93	.87 ± .05	.88 ± .05	.88
8	3	.96 ± .02	.87 ± .05	.92	.88 ± .05	.83 ± .06	.86
9	4				.91 ± .04	.78 ± .07	.85
5	5	.91 ± .04	.95 ± .03	.93	.99 ± .01	.92 ± .04	.96
6	6	.92 ± .03	.82 ± .06	.87	.93 ± .03	.80 ± .07	.87
7	7	.94 ± .03	.90 ± .04	.92	.95 ± .02	.89 ± .04	.92
8	8	.96 ± .02	.93 ± .03	.95	.94 ± .03	.94 ± .03	.94
9	9	.91 ± .04	.78 ± .07	.85			
5	10	.92 ± .03	.88 ± .05	.90	.84 ± .06	.94 ± .03	.89

Form	Day	Form 5 Day 5 Stanford	Iowa	Av.	Form 5 Day 10 Stanford	Iowa	Av.
6	1	.90 ± .04	.91 ± .04	.91	.92 ± .03	.81 ± .07	.87
7	2	.90 ± .04	.94 ± .03	.92	.93 ± .03	.91 ± .04	.92
8	3	.94 ± .03	.87 ± .05	.91	.90 ± .04	.80 ± .07	.85
9	4	.91 ± .04	.95 ± .03	.93	.92 ± .03	.88 ± .05	.90
5	5				.88 ± .05	.94 ± .03	.91
6	6	.93 ± .03	.97 ± .01	.95	.91 ± .04	.91 ± .04	.91
7	7	.96 ± .02	.93 ± .03	.95	.92 ± .03	.95 ± .03	.94
8	8	.91 ± .03	.97 ± .01	.94	.94 ± .03	.95 ± .02	.95
9	9	.99 ± .01	.92 ± .04	.96	.84 ± .06	.94 ± .03	.89
5	10	.88 ± .05	.94 ± .03	.91			

The coefficients of correlation for which the time elapsing is:

2 days, are:	.95	.93	.91	.90	.93	.94,		Av., .93
3 days, are:	.89	.89	.91					Av., .90
4 days, are:	.87	.87	.92					Av., .89
5 days, are:	.95	.91	.94	.85	.92			Av., .91
7 days, are:	.92	.94	.94	.83	.91	.86	.92	Av., .90
9 days, are:	.90	.96	.96	.94				Av., .94
10 days, are:	.91	.91						Av., .91
14 days, are:	.90	.88	.87	.86				Av., .88
16 days, are:	.87	.88						Av., .88
17 days, are:	.85							.85
18 days, are:	.85							.85
19 days, are:	.92							.92
21 days, are:	.87							.87

The probable errors of these coefficients decrease from ±.06 to ±.02 as the coefficients increase from .85 to .96.

The time intervals for which the average coefficient (determined by a total of from one to seven coefficients) lies between .94 and .90, are in order 9, 2, 19, 5, 10, and 7 days, the average time being 9 days; the time intervals for which the average coefficient lies between .89 and .85, are in order 3, 14, 16, 4, 21, 18, and 17, average 13. The twenty-four coefficients for which the time interval is one week or less, when averaged give .91; similarly, the 10 coefficients for which the time interval is from one to two weeks, .91; while the 6 coefficients whose time interval is from two to three weeks, .87. From these facts it would appear that an increase in time interval tends to a slight reduction only, if any at all, in the coefficient of correlation between scores in identical or closely similar material, in case practice on such material has intervened.

The probable errors of the coefficients in all these determinations are fairly low. Consideration of them merely makes the conclusion of the negligibility of the time factor more emphatic.

THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL GRADUATES

In the State Normal School at Trenton, New Jersey, the Thorndike Intelligence Examination for High School Graduates was given in 1919 to a group of 170 students, of whom a retest was made in 1920 approximately one year later. The tests used in 1919 were: Part I Form C, Part I Form D, Part II Form B, and Part III Form B. In 1920 Part I Form E, Part I Form F, Part II Form C, Part III Form C were employed. These tests require approximately three hours' work from the subjects, Part I with its Practice Form consuming about half the time allowed. The test is written in order: Practice Form, Part I, Part I, Part II, and Part III. The coefficients of correlation between the scores in the two forms of Part I and those in Part II and Part III are as shown in Table III.

TABLE III

COEFFICIENTS OF CORRELATION OF PART I VS. PARTS II AND III OF THE THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL GRADUATES, 1919 AND 1920

$N = 170$

	IC+ID, '19	IIB+IIIB, '19	IE+IF, '20
IIB + IIIB, '19	.71 ± .03		
IE + IF, '20	.88 ± .02	.73 ± .03	
IIC + IIIC, '20	.69 ± .04	.77 ± .03	.70 ± .03

The figures .71 and .69 give a comparison between Part I as written in 1919 and Parts II and III combined,[3] as written on the same day and a year later. Similarly, the figures .70 and .73 may be noted as comparing Part I as written in 1920 with Parts II and III combined, as written on the same day and a year earlier. Parts II and III combined written in 1919, when plotted against Part I written in 1919 and in 1920, give coefficients of correlation of .71 and .73; Parts II and III combined written in 1920 against Part I in 1920 and 1919, give .69 and .70. The figure .88 measures the correspondence between the Part I papers in 1919 and in 1920, and the figure .77 that between the Parts II and III combined. Consideration of these figures indicates that, for these 170 individuals, the lapse of a year had no greater effect upon their relative standing than did the lapse of a few minutes. In fact, the coefficient between Part I written in 1920 and Parts II and III combined written the same year is three points less than that between the same Part I and Parts II and III combined written one year earlier, while Part I written in 1919 when correlated with Parts II and III combined written in 1919 and in 1920, shows only two points difference in favor of the few minutes' time interval. Parts II and III combined written in 1919 show two points lower coefficient when plotted against Part I written the same day and Part I written a year later; while Parts II and III combined written in 1920 plotted against Part I written the same year and a year earlier show a difference of half a point in favor of the year's interval. Whatever factors tend to make the performance of an individual a variable rather than a constant, appear to be as much operative during the two halves of a continuous three-hour test as during either half of this three-hour test and either half of a similar test with a year of time intervening.

I. E. R.[4] TESTS OF SELECTIVE AND RELATIONAL THINKING, GENERALIZATION AND ORGANIZATION

In May, 1922, and in May, 1923, approximately 10,000 high school pupils were tested and retested with a battery of fifteen

[3] Part I in the forms used consists of 143 items arranged in thirteen tests of the type popularized in the Army Alpha test: Following Directions, Rearranging Sentences, Arithmetic Calculation, Arithmetic Problems, Information, Opposites, Common Sense, Number Series, Mixed Relations, Number Selection, Verbal Fallacies, Logical Reasoning, Form Recognition. Part II consists of 127 items arranged in eight tests: Reading Comprehension, Sentence Completion, Picture Completion, Picture Analogies, Geometrical Analogies, Algebraic Computation, Mechanical Knowledge, General Information. Part III consists of 24 items arranged in two tests of Reading Comprehension and one in Sentence Completion.

[4] I. E. R. is a technical abbreviation for Institute of Educational Research.

tests chosen especially to reveal ability to make selections from data, see logical relations, generalize from data, and organize thinking. These tests are so planned as to attempt to test these abilities in verbal, numerical and space representation material in each of the four types of thinking.

Coefficients of correlation for two groups of 250 cases each, selected from first-year high school students in the same year of age, were computed, plotting the score in the eight tests in the battery labelled Selective and Relational Thinking [5] against the score in the seven tests in the battery labelled Generalization and Organization,[6] written the same day and a year apart, as well as coefficients of self-correlation of each battery written one year apart.

These coefficients of self-correlation were:

	Group I	Group II	Average
Sel. Rel. ('22 *vs.* '23)	.81 ± .02	.82 ± .02	.82
Gen. Org. ('22 *vs.* '23)	.70 ± .03	.67 ± .03	.69

The coefficients of correlation of one battery against the other are as follows:

	Group I		Group II		Average	
	Gen. '22	Gen.'23	Gen. '22	Gen. '23	Gen. '22	Gen. '23
Sel. Rel. '22	.73 ± .03	.66 ± .03	.68 ± .03	.71 ± .03	.71	.69
Sel. Rel. '23	.69 ± .03	.69 ± .03	.66 ± .03	.72 ± .03	.68	.71

The average coefficient of correlation of Selective and Relational against Generalization and Organization written the same day is .71; written a year apart, .69.

Coefficients of correlation were also computed using the verbal material [7] in the total battery against the numerical and spatial,[8] for the same day and a year apart as well as the coefficients of self-correlation a year apart. The coefficients were:

	Group I	Group II	Average
Verbal ('22 *vs.* '23)	.76 ± .03	.74 ± .03	.75
Numerical and Spatial ('22 *vs.* '23)	.79 ± .03	.80 ± .02	.80

The coefficients of correlation were calculated for the verbal material against the numerical and spatial. They are as follows:

[5] Including 189 items so weighted as to make possible a total score of 257.
[6] Including 99 items so weighted as to make possible a total score of 198.
[7] Including 170 items so weighted as to make possible a total score of 242.
[8] Including 118 items so weighted as to make possible a total score of 213.

	Group I		Group II		Average	
	N+S '22	N+S '23	N+S '22	N+S '23	N+S '22	N+S '23
Verbal '22	.56 ± .04	.60 ± .04	.58 ± .04	.56 ± .04	.57	.58
Verbal '23	.67 ± .03	.59 ± .04	.57 ± .04	.58 ± .04	.62	.59

The average coefficient of verbal versus numerical and spatial material written the same day is .58; written a year apart, .60. For these 500 ninth year students, the amount of variation within the two hours' time required for the test to be written is evidently very nearly the same as occurs after an interval of a year's time. Whatever are the causes that make these individuals vary in their mental work upon such tests, they are operative largely if not wholly in independence of the time factor.

When the number of cases used is so large, the probable errors of the determinations are small. The conclusions drawn from the data are less liable to mistake in interpretation than if the number had been small.

EIGHTEEN HOURS' TESTING OF TWENTY ADULTS

In May, 1924, twenty adults were given a nine-hour battery of tests, and a repeat test was given seven days later.[9] Many kinds of material were used, including I. E. R. Sentence Completions, I. E. R. Arithmetic Problems, the Thorndike Non-Verbal Intelligence Examination, the Briggs Analogies Test, a Mixed Relations Test, the Burgess Reading Test, and the Thorndike Intelligence Examination for High School Graduates. Coefficients of self-correlation were found as shown in Table IV.

TABLE IV

COEFFICIENTS OF SELF-CORRELATION[10] OF TESTS USED IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Time	r
Completion, 60′ work	Day 1 *vs.* Day 2	.91 ± .03
Arithmetic, 60′ work	"	.87 ± .04
Easy Completion	"	.81 ± .06
Hard Completion	"	.78 ± .07
Easy Arithmetic	"	.94 ± .02
Hard Arithmetic	"	.75 ± .07
Thorndike Intelligence Exam. for H. S. Grads.	"	.96 ± .02

[9] Short rest periods were allowed between tests, and one hour at midday was vacated for luncheon.

[10] These figures do not give the true reliability of these tests, the number of cases being small, but they are given in order that the reader, if he so desires, may compare them with the coefficients of inter-correlation listed later.

TABLE IV—(*Continued*)

Briggs Analogies	Day 1 *vs.* Day 2	.83 ± .05
Mixed Relations	"	.83 ± .05
Thorndike Non-Verbal	Day 1 A. M. *vs.* P. M.	.90 ± .04
Thorndike Non-Verbal	Day 2 A. M. *vs.* P. M.	.91 ± .03
Burgess Reading	Day 1 *vs.* Day 2	.85 ± .05

To enable comparisons between material written the same day and after a lapse of seven days, correlation coefficients were computed between various combinations of the data. Table V includes the results for sixty minutes' work in completing sentences on the first and second days.

TABLE V

Coefficients of Correlation with One Hour's Work in Completions in 18-Hour Testing Program. $N = 20$

Test	Day	Completion 60′ Day 1	Completion 60′ Day 2	Average Same Day	Average 7 Days Apart
Arithmetic, 60′	1	.87 ± .04	.76 ± .07	.77	.75
Arithmetic, 60′	2	.74 ± .08	.67 ± .09		
Th. Int. Ex. H. S. Gr.	1	.84 ± .05	.88 ± .04	.87	.89
Th. Int. Ex. H. S. Gr.	2	.90 ± .04	.90 ± .04		
Briggs Analogies	1	.79 ± .06	.66 ± .09	.70	.72
Briggs Analogies	2	.77 ± .07	.60 ± .10		
Mixed Relations	1	.87 ± .04	.78 ± .07	.84	.83
Mixed Relations	2	.88 ± .04	.81 ± .06		
Th. Non-Verbal (G + A)	1	.76 ± .07	.76 ± .07	.80	.81
Th. Non-Verbal (E + A)	1	.86 ± .05	.84 ± .05		
Th. Non-Verbal (C + B)	2	.73 ± .08	.70 ± .08	.77	.77
Th. Non-Verbal (B + B)	2	.84 ± .05	.81 ± .06		
Burgess Reading	1	.66 ± .09	.56 ± .11	.67	.63
Burgess Reading	2	.69 ± .09	.67 ± .09		

In no case is the difference between averages greater than .04, while the average of the seven average coefficients[11] is the same, .77.

Table VI shows similar data for sixty minutes' work on the first and second days in solving arithmetic problems.

[11] The probable errors of all these coefficients are rather large, since the number of cases is small. For this reason it seems wiser to discuss averages of groups of coefficients. It is recognized of course that the meaning of a coefficient of correlation is not identical at different locations between zero and plus or minus one, and that averages of coefficients of widely different magnitude are misleading. With awareness of that consideration, the procedure used still seemed advisable.

TABLE VI

COEFFICIENTS OF CORRELATION WITH ONE HOUR'S WORK IN ARITHMETIC IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Arithmetic 60′ Day 1	Arithmetic 60′ Day 2	Average Same Day	Average 7 Days Apart
Completion, 60′	1	.87 ± .04	.74 ± .07	.77	.75
Completion, 60′	2	.76 ± .06	.67 ± .09		
Th. Int. Ex. H. S. Gr.	1	.87 ± .04	.77 ± .06	.78	.83
Th. Int. Ex. H. S. Gr.	2	.88 ± .03	.68 ± .08		
Briggs Analogies	1	.79 ± .06	.62 ± .09	.71	.66
Briggs Analogies	2	.70 ± .08	.63 ± .09		
Mixed Relations	1	.91 ± .03	.80 ± .05	.80	.80
Mixed Relations	2	.80 ± .05	.69 ± .08		
Th. Non-Verbal (G + A)	1	.74 ± .07	.72 ± .07	.77	.80
Th. Non-Verbal (E + A)	1	.88 ± .03	.80 ± .05		
Th. Non-Verbal (C + B)	2	.75 ± .07	.73 ± .07	.79	.81
Th. Non-Verbal (B + B)	2	.88 ± .03	.82 ± .05		
Burgess Reading	1	.59 ± .10	.59 ± .10	.59	.61
Burgess Reading	2	.62 ± .09	.58 ± .10		

There are two differences in averages of .05, one in favor of the small interval of time and the other contrariwise; the averages of the seven averages differ by less than .01, that for the same day being .74, that for days one week apart being .75.

The Briggs Analogies Test yields, in comparison with the other data, results as shown in Table VII.

TABLE VII

COEFFICIENTS OF CORRELATION WITH BRIGGS ANALOGIES TESTS IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Briggs Day 1	Briggs Day 2	Average Same Day	Average 7 Days Apart
Completion, 60′	1	.79 ± .06	.77 ± .06	.70	.72
Completion, 60′	2	.66 ± .09	.60 ± .10		
Arithmetic, 60′	1	.79 ± .06	.70 ± .08	.71	.66
Arithmetic, 60′	2	.62 ± .09	.63 ± .09		
Th. Int. Ex. H. S. Gr.	1	.68 ± .08	.64 ± .09	.72	.70
Th. Int. Ex. H. S. Gr.	2	.75 ± .07	.75 ± .07		
Mixed Relations	1	.83 ± .05	.80 ± .05	.80	.80
Mixed Relations	2	.79 ± .06	.76 ± .06		
Burgess Reading	1	.61 ± .09	.60 ± .10	.65	.70
Burgess Reading	2	.80 ± .05	.69 ± .08		

The average of the five averages for the same day and for days one week apart is exactly the same, i.e., .71.

The data from the Mixed Relations, when compared with the data from other tests, yield results as shown in Table VIII.

TABLE VIII

COEFFICIENTS OF CORRELATION WITH MIXED RELATIONS TESTS IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Mixed Relations Day 1	Mixed Relations Day 2	Average Same Day	Average 7 Days Apart
Completion, 60′	1	.87 ± .04	.88 ± .03	.84	.83
Completion, 60′	2	.78 ± .06	.81 ± .05		
Arithmetic, 60′	1	.91 ± .03	.80 ± .05	.80	.80
Arithmetic, 60′	2	.80 ± .05	.69 ± .08		
Th. Int. Ex. H. S. Gr.	1	.81 ± .05	.82 ± .05	.84	.83
Th. Int. Ex. H. S. Gr.	2	.84 ± .04	.86 ± .04		
Briggs Analogies	1	.83 ± .05	.79 ± .06	.80	.80
Briggs Analogies	2	.80 ± .05	.76 ± .06		
Burgess Reading	1	.57 ± .10	.49 ± .11	.62	.59
Burgess Reading	2	.69 ± .08	.66 ± .09		

The average of the five averages for the same day is .78; for days one week apart is .77.

The Thorndike Intelligence Examination for High School Graduates gives results as shown in Table IX.

TABLE IX

COEFFICIENTS OF CORRELATION WITH THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL GRADUATES IN 18-HOUR TESTING PROGRAM

$N = 20$

Test	Day	Th. Int. Ex. H. S. Gr. Day 1	Th. Int. Ex. H. S. Gr. Day 2	Average Same Day	Average 7 Days Apart
Completion, 60′	1	.84 ± .04	.90 ± .03	.89	.87
Completion, 60′	2	.88 ± .03	.90 ± .03		
Arithmetic, 60′	1	.87 ± .04	.88 ± .03	.78	.83
Arithmetic, 60′	2	.77 ± .06	.68 ± .08		
Briggs Analogies	1	.68 ± .08	.75 ± .07	.72	.70
Briggs Analogies	2	.64 ± .09	.75 ± .07		
Mixed Relations	1	.81 ± .05	.84 ± .04	.84	.83
Mixed Relations	2	.82 ± .05	.86 ± .04		
Th. Non-Verbal (A. M.)	1	.73 ± .07	.78 ± .06	.82	.82
Th. Non-Verbal (P. M.)	1	.85 ± .04	.91 ± .03		

Th. Non-Verbal (A. M.)	2	.70 ± .08	.79 ± .06	.80	.81
Th. Non-Verbal (P. M.)	2	.83 ± .05	.89 ± .03		
Burgess Reading	1	.63 ± .09	.64 ± .09	.66	.65
Burgess Reading	2	.66 ± .09	.69 ± .08		

The averages of the seven averages for the same day and for days one week apart are identical, i.e., .79.

The Thorndike Non-Verbal Intelligence Test was written twice each day of the test. The coefficients of correlation which it offers with other tests are as shown in Table X.

TABLE X

Coefficients of Correlation with Thorndike Non-Verbal Intelligence Test in 18-Hour Testing Program. $N = 20$

Test	Day	Non-Verbal Day 1a	Non-Verbal Day 1b	Non-Verbal Day 2a	Non-Verbal Day 2b	Average Same Day	Average 7 Days Apart
Co. 60′	1	.76 ± .06	.86 ± .04	.73 ± .07	.84 ± .04	.78	.79
Co. 60′	2	.76 ± .06	.84 ± .04	.70 ± .08	.81 ± .05		
Ar. 60′	1	.74 ± .07	.88 ± .03	.75 ± .07	.88 ± .03	.79	.79
Ar. 60′	2	.72 ± .07	.80 ± .05	.73 ± .07	.82 ± .05		
Th. I. E. H. S. Gr.	1	.73 ± .07	.85 ± .04	.70 ± .08	.83 ± .05	.76	.78
Th. I. E. H. S. Gr.	2	.78 ± .06	.91 ± .03	.79 ± .06	.89 ± .03		

The average coefficient of correlation on the same day is .78; on days one week apart, .79.

The comparisons in non-verbal material in the sections written on the forenoon and afternoon of the same day, and those written similarly on days one week apart, are found to be:

	Forenoon Day 1	Afternoon Day 1	Average Same Time of Day	Average Different Time of Day
Written in forenoon of Day 2	.93 ± .02	.95 ± .01	.95	.92
Written in afternoon of Day 2	.88 ± .03	.96 ± .01		

The Burgess Reading Test, because of its meager difficulty, became chiefly a speed test for the examinees. It shows coefficients of correlation with other tests as indicated in Table XI.

The average of the five averages for the same day and for days one week apart is the same, .64.

TABLE XI

COEFFICIENTS OF CORRELATION WITH BURGESS READING TESTS IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Burgess Reading Day 1	Burgess Reading Day 2	Average Same Day	Average 7 Days Apart
Completion, 60′	1	.66 ± .09	.69 ± .08	.67	.63
Completion, 60′	2	.56 ± .10	.67 ± .08		
Arithmetic, 60′	1	.59 ± .10	.62 ± .09	.59	.61
Arithmetic, 60′	2	.59 ± .10	.58 ± .10		
Th. Int. Ex. H. S. Gr.	1	.63 ± .09	.66 ± .09	.66	.65
Th. Int. Ex. H. S. Gr.	2	.64 ± .09	.69 ± .08		
Briggs Analogies	1	.61 ± .09	.80 ± .05	.65	.70
Briggs Analogies	2	.60 ± .10	.69 ± .08		
Mixed Relations	1	.57 ± .10	.69 ± .08	.62	.59
Mixed Relations	2	.49 ± .11	.66 ± .09		

The completion and arithmetic material included certain tasks so easy for the group as to offer a minimum of difficulty and a maximum opportunity for speed in accomplishment, while other tasks of the same kind were much harder.

The coefficients of inter-correlation of these groups were as shown in Table XII, charting the Easy Completions against the Hard Completions and against the Easy and Hard Arithmetic.

TABLE XII

COEFFICIENTS OF CORRELATION WITH EASY COMPLETIONS IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Completion Easy Day 1	Completion Easy Day 2	Average Same Day	Average 7 Days Apart
Completion, Hard	1	.60 ± .10	.71 ± .07	.69	.70
Completion, Hard	2	.68 ± .08	.78 ± .06		
Arithmetic, Easy	1	.83 ± .05	.78 ± .06	.79	.82
Arithmetic, Easy	2	.85 ± .04	.74 ± .07		
Arithmetic, Hard	1	.62 ± .09	.54 ± .11	.59	.63
Arithmetic, Hard	2	.71 ± .07	.56 ± .10		

The average of the three averages for the same day is .69; for days a week apart, .72. From setting the Easy Arithmetic against the Easy and Hard Completions and the Hard Arithmetic, results appear as in Table XIII.

TABLE XIII

COEFFICIENTS OF CORRELATION WITH EASY ARITHMETIC IN 18-HOUR TESTING PROGRAM. $N = 20$

Test	Day	Arith. Easy Day 1	Arith. Easy Day 2	Av. Same Day	Av. 7 Days Apart
Completion, Easy	1	.83 ± .05	.85 ± .04	.79	.82
Completion, Easy	2	.78 ± .06	.74 ± .07		
Completion, Hard	1	.60 ± .10	.56 ± .10	.61	.56
Completion, Hard	2	.55 ± .11	.61 ± .09		
Arithmetic, Hard	1	.68 ± .08	.70 ± .08	.75	.74
Arithmetic, Hard	2	.78 ± .06	.81 ± .05		

The average of the three averages for the same day is .72; for days one week apart, is .71.

The Hard Completions set against the Hard Arithmetics give the following:

Test	Day	Completion Hard Day 1	Completion Hard Day 2	Av. Day 1	Av. Day 2
Arithmetic, Hard	1	.80 ± .05	.66 ± .09	.69	.57
Arithmetic, Hard	2	.48 ± .12	.57 ± .10		

This is the only set of coefficients of inter-correlation in the Easy and Hard Completions and Arithmetics showing marked divergence from the usual expectation.

When the six averages for the same day are averaged, the resulting figure is .69; that for days one week apart is .67.

The general conclusion from the data obtained from eighteen hours' testing in two sections one week apart is that under the specified conditions of testing for the twenty persons concerned, the variability due to the time factor is negligible, if not zero. This conclusion seems the more justifiable when due consideration of the size of the probable errors of the coefficients is given.

THORNDIKE TEST OF WORD KNOWLEDGE

Pupils in Grades 4 to 8 in a public school in New York City were tested with Forms A, B, C, D (used in rotation) of the Thorndike Test of Word Knowledge. These pupils, numbering 35 in the fourth grade, 58 in the fifth grade, 166 in the sixth grade, 190 in the seventh grade, 219 in the eighth grade, or a total of 668 in all grades, were retested in 10 days with the same forms so rotated that no child wrote upon the same form as in the earlier test.

In order to divide each test to find a coefficient of self-correlation, the scores on alternate groups of five words were summated. Coefficients of correlation are reported thus for odd and even fives, fifty words in each half.

The total score for the first day, when plotted against the total score for the second day, gives coefficients of correlation as follows:

Grade	4	5	6	7	8	Total
N =	35	58	166	190	219	668
r =	.69 ± .08	.76 ± .04	.76 ± .02	.83 ± .02	.84 ± .02	.86 ± .01

The coefficients of inter-correlation between scores from sums of the odd and even fives for each grade and for the total group are as shown in Table XIV.

TABLE XIV

Coefficients of Correlation in Thorndike Test of Word Knowledge
Grades 4 to 8
Total N = 668

Grade	Odds Day	Evens Day 1	Evens Day 2	Average Same Day	Average 10 Days Apart
4	1	.74 ± .05	.63 ± .07	.73	.58
4	2	.52 ± .08	.72 ± .05		
5	1	.82 ± .03	.67 ± .05	.80	.70
5	2	.73 ± .04	.78 ± .03		
6	1	.73 ± .02	.64 ± .03	.72	.65
6	2	.66 ± .03	.70 ± .03		
7	1	.75 ± .02	.73 ± .02	.82	.74
7	2	.75 ± .02	.88 ± .01		
8	1	.75 ± .02	.75 ± .02	.75	.73
8	2	.71 ± .02	.75 ± .02		
Total	1	.83 ± .01	.76 ± .01	.83	.78
Total	2	.79 ± .01	.82 ± .01		

There is greater difference between the average coefficients of correlation for these data in Word Knowledge secured with a ten days' time interval and those written the same day than in any other material thus far examined, the average of the averages for the same day being .78, that for the time interval, .70. That this is due to intrinsically greater variability in Word Knowledge over a lapse of time than in other forms of learning, seems im-

probable. It seems the more reasonable that the test material was less suited to pupils in the lower grades. The fact that the differences in the coefficients of correlation notably decrease in the eighth grade, adds strength to this supposition, the differences being, by Grades 4 to 8 in order, .15, .10, .07, .08, .02.

I. E. R. TESTS OF SENTENCE COMPLETION AND ARITHMETIC PROBLEMS

In June, 1924, 205 sixth grade pupils in Public School No. 6, Borough of Manhattan, New York City, were tested on the I. E. R. Tests of Sentence Completion and Arithmetic Problems. Each series was subdivided into pages of nearly equal difficulty *inter se*, but of increasing difficulty from page to page. The 1st, 3rd, 5th, etc., pages of Completions, and the 2nd, 4th, 6th, etc., pages of Arithmetic Problems were written at one sitting of two hours, and the remaining papers of each at a second sitting of two hours' duration;[12] the two sittings being in the forenoon and afternoon of the same day, from 9:30 to 11:30 A.M. and from 1:00 to 3:00 P.M. No school work intervened between sittings.

The coefficient of self-correlation of the Completions for forenoon and afternoon was .70; of the Arithmetic, .69. The coefficients of inter-correlation are as follows:

	Arith. A. M.	Arith. P. M.	Average Same Sitting	Average Different Sittings
Completion, A. M.	.55 ± .03	.63 ± .03	.54	.55
Completion, P. M.	.46 ± .04	.53 ± .03		

The lapse of three and one half hours as compared with the time during a two-hour sitting has thus no apparent influence upon the variability of the 205 children thus tested.

[12] Rest periods of two to five minutes were taken each forty minutes.

CHAPTER IV

THE DATA AND THEIR TREATMENT (*Continued*)

PROLONGED BATTERY OF TESTS IN GRADE 7

In the series of experiments for the New York State Commission on Ventilation undertaken to find the effect upon the mental work of children and adults of various conditions of carbon dioxide content of the air, a large mass of test data was accumulated. The experiments and conclusions are reported elsewhere.[1] Certain data from parts of these experiments have been herein utilized to investigate the element of time as a factor in the variability of an individual's performance of a mental function.

Fifty children in Grade 7 in Public School No. 51, New York City, were tested in September and October and November with a battery of many tests, including Arithmetic, Visual Vocabulary, Reading, Trabue Sentence Completions, Analogies, Mixed Relations, Ruger Proverbs, Spelling, Courtis Arithmetic Computation, Woody Arithmetic Addition, Subtraction and Division, Handwriting and the like. All these abilities were re-tested near mid-year, the time interval (for all subjects except handwriting) being from 100 days in Woody Subtraction to 136 days in Analogies, the average time interval for fifteen tests being 115 days.

The coefficients of self-correlation [2] of the material used from September to January, together with the time interval in days, are as follows:

[1] *Report of the New York State Commission on Ventilation*, 1915.

McCall, W. A.: *Correlation of Some Psychological and Educational Measurements.* 1916.

Thorndike, E. L., McCall, W. A., and Chapman, J. C.: *Ventilation in Relation to Mental Work.* 1916.

Thorndike, E. L., Ruger, G. J., and McCall, W. A.: "The Effects of Outside Air and Recirculated Air upon Intellectual Achievement and Improvement." *School and Society*, 3: 679–84, May 6, 1916.

[2] These figures do not express the true reliability of these tests, the number of cases being small, and the range of ability restricted; but they are given here that the reader who so desires may compare them with the coefficients of inter-correlation reported hereinafter.

	r	Time Interval in Days
Arithmetic VI	.50 ± .07	135
Visual Vocabulary	.74 ± .04	133
Reading	.53 ± .07	134
Completion	.67 ± .05	134
Metropolitan I	.66 ± .05	135
Metropolitan III	.71 ± .05	136
Ruger Proverbs	.58 ± .06	101
Mixed Relations	.55 ± .07	101
Visual Vocabulary XII	.68 ± .05	101
Spelling	.91 ± .02	103
Courtis (6)	.64 ± .06	103
Courtis (8)	.70 ± .05	103
Woody (÷)	.40 ± .08	102
Woody (−)	.51 ± .07	100
Woody (+)	.49 ± .07	103

The general arithmetic test (called Arithmetic VI) shows coefficients of inter-correlation [3] with other tests according to Table XV.

TABLE XV

COEFFICIENTS OF CORRELATION WITH ARITHMETIC VI TEST IN GRADE 7

PROGRAM OF TESTS

TIME INTERVAL IN DAYS

$N = 50$

Test	Arith. VI Sept.	Time Interval	Arith. VI Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Vis. Voc. Sept.	.17 ± .09	0	.24 ± .09	135	.29	.29
Vis. Voc. Jan.	.34 ± .08	133	.40 ± .08	2		
Reading Sept.	.12 ± .09	0	.26 ± .09	135	.31	.34
Reading Jan.	.42 ± .08	134	.50 ± .07	1		
Completions, Sept.	.28 ± .09	0	.32 ± .09	135	.27	.22
Completions, Jan.	.12 ± .09	134	.25 ± .09	1		
Met. I Sept.	.29 ± .09	0	.43 ± .08	135	.37	.38
Met. I Jan.	.32 ± .09	135	.44 ± .08	0		
Met. III Sept.	.57 ± .06	0	.61 ± .06	135	.53	.54
Met. III Jan.	.47 ± .07	136	.49 ± .07	1		
Ruger Prov. Sept.	.18 ± .09	20	.42 ± .08	115	.24	.29
Ruger Prov. Jan.	.16 ± .09	121	.29 ± .09	14		

[3] In this group of coefficients of correlation, as in all the other groups discussed in this chapter, the probable errors are large in comparison with the size of the coefficients. It is largely for this reason that the discussion is confined to averages rather than to single coefficients, although it is recognized that coefficients of greatly differing magnitudes cannot appropriately be averaged.

TABLE XV (*Continued*)

Mixed Rel. Oct.	.22 ± .09	20	.30 ± .09	115	.23	.22
Mixed Rel. Jan.	.13 ± .09	121	.24 ± .09	14		
Vis. Voc. XII Oct.	.19 ± .09	21	.25 ± .09	114	.23	.28
Vis. Voc. XII Jan.	.31 ± .09	122	.27 ± .09	13		
Spelling Oct.	.18 ± .09	22	.28 ± .09	113	.22	.22
Spelling Jan.	.16 ± .09	125	.26 ± .09	10		
Courtis (6) Oct.	.48 ± .07	22	.55 ± .07	113	.48	.45
Courtis (6) Jan.	.34 ± .09	125	.48 ± .07	10		
Courtis (8) Oct.	.54 ± .07	23	.60 ± .06	112	.52	.53
Courtis (8) Jan.	.46 ± .08	126	.50 ± .07	9		
Woody (÷) Oct.	.19 ± .09	24	−.09 ± .09	111	.23	.03
Woody (÷) Jan.	.15 ± .09	126	.26 ± .09	9		
Woody (−) Oct.	.47 ± .07	27	.37 ± .08	108	.40	.39
Woody (−) Jan.	.41 ± .08	127	.33 ± .09	8		
Woody (+) Oct.	.44 ± .08	29	.29 ± .09	106	.29	.22
Woody (+) Jan.	.15 ± .09	132	.14 ± .09	3		

The coefficients of correlation between abilities thus found are much lower than those found for the twenty adults tested the same day and one week apart (*vide* pp. 13 ff), but the change over approximately one-third to one-half a school year in material some of which was connected with instruction during the period is surprisingly small. The only notable decrease in coefficient is in the second general arithmetic as compared with the first Woody division test. Except for this one difference of .20 the other changes balance each other in trend up and down, the average for the fourteen averages for the short time interval being .33, that for the long time interval being .31.

The data for the visual vocabulary tests when used against other tests give the results as shown in Table XVI, the time interval again being indicated in the table.

The single differences in the average coefficients of correlation are less than those found in the case of the general arithmetic material, but the averages of the fourteen averages remain equally far apart, being .36 for the short time interval and .34 for the long time interval.

The reading test data yield the results as given in Table XVII.

TABLE XVI

COEFFICIENTS OF CORRELATIONS WITH VISUAL VOCABULARY TESTS IN GRADE 7 PROGRAM OF TESTS

TIME INTERVALS IN DAYS

$N = 50$

Test	Vis. Voc. Sept.	Time Interval	Vis. Voc. Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.17 ± .09	0	.34 ± .08	133	.29	.29
Arith. VI Jan.	.24 ± .09	135	.40 ± .08	2		
Reading Sept.	.31 ± .09	0	.35 ± .08	133	.41	.38
Reading Jan.	.40 ± .08	134	.51 ± .07	1		
Completions Sept.	.60 ± .06	0	.60 ± .06	133	.56	.56
Completions Jan.	.52 ± .07	134	.52 ± .07	1		
Met. I Sept.	.40 ± .08	0	.45 ± .08	133	.47	.45
Met. I Jan.	.44 ± .08	135	.53 ± .07	2		
Met. III Sept.	.47 ± .07	0	.63 ± .06	133	.59	.57
Met. III Jan.	.51 ± .07	136	.70 ± .05	3		
Ruger Prov. Sept.	.35 ± .08	20	.41 ± .08	113	.30	.33
Ruger Prov. Jan.	.19 ± .09	121	.30 ± .09	12		
Mixed Rel. Sept.	.32 ± .09	20	.38 ± .08	113	.30	.28
Mixed Rel. Jan.	.18 ± .09	121	.28 ± .09	12		
Vis. Voc. XII Sept.	.61 ± .06	21	.54 ± .07	112	.58	.55
Vis. Voc. XII Jan.	.55 ± .07	122	.55 ± .07	11		
Spelling Oct.	.47 ± .07	22	.54 ± .07	111	.50	.50
Spelling Jan.	.45 ± .08	125	.52 ± .07	8		
Courtis (6) Oct.	.25 ± .09	22	.34 ± .08	111	.29	.26
Courtis (6) Jan.	.18 ± .09	125	.32 ± .09	8		
Courtis (8) Oct.	.17 ± .09	23	.30 ± .09	110	.26	.23
Courtis (8) Jan.	.16 ± .09	126	.34 ± .08	7		
Woody (÷) Oct.	.20 ± .09	24	.29 ± .09	109	.23	.20
Woody (÷) Jan.	.10 ± .09	126	.25 ± .09	7		
Woody (−) Oct.	−.20 ± .09	27	.06 ± .10	106	.05	.06
Woody (−) Jan.	.05 ± .10	127	.29 ± .09	6		
Woody (+) Oct.	.18 ± .09	29	.22 ± .09	104	.20	.16
Woody (+) Jan.	.09 ± .09	132	.21 ± .09	1		

Larger differences in the corresponding average coefficients of correlation are to be found in Table XVII than in the two preceding groups of data; the average of the fourteen averages, however, is .35 for the short interval of time and .36 for the long interval.

TABLE XVII

COEFFICIENTS OF CORRELATION WITH READING TESTS IN GRADE 7
PROGRAM OF TESTS
TIME INTERVAL IN DAYS
$N = 50$

Test	Reading Sept.	Time Interval	Reading Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.12 ± .09	0	.42 ± .08	134	.31	.34
Arith. VI Jan.	.26 ± .09	135	.50 ± .07	1		
Vis. Voc. Sept.	.31 ± .09	0	.40 ± .08	134	.41	.38
Vis. Voc. Jan.	.35 ± .08	133	.51 ± .07	1		
Completions Sept.	.46 ± .08	0	.51 ± .07	134	.50	.46
Completions Jan.	.41 ± .08	134	.54 ± .07	0		
Met. I Sept.	.41 ± .08	0	.46 ± .08	134	.42	.45
Met. I Jan.	.44 ± .08	135	.43 ± .08	1		
Met. III Sept.	.41 ± .08	0	.61 ± .06	134	.47	.50
Met. III Jan.	.38 ± .08	136	.52 ± .07	2		
Ruger Prov. Oct.	.27 ± .09	20	.43 ± .08	114	.36	.40
Ruger Prov. Jan.	.27 ± .09	121	.45 ± .08	13		
Mixed Rel. Oct.	.13 ± .09	20	.50 ± .07	114	.29	.40
Mixed Rel. Jan.	.29 ± .09	121	.44 ± .08	13		
Vis. Voc. XII Oct.	.31 ± .09	21	.43 ± .08	113	.50	.42
Vis. Voc. XII Jan.	.40 ± .08	122	.68 ± .05	12		
Spelling Oct.	.21 ± .09	22	.38 ± .08	112	.29	.26
Spelling Jan.	.13 ± .09	125	.36 ± .08	9		
Courtis (6) Oct.	.42 ± .08	22	.63 ± .06	112	.51	.50
Courtis (6) Jan.	.36 ± .08	125	.59 ± .06	9		
Courtis (8) Oct.	.33 ± .09	23	.49 ± .07	111	.42	.43
Courtis (8) Jan.	.37 ± .08	126	.51 ± .07	8		
Woody (÷) Oct.	.09 ± .09	24	.05 ± .10	110	.18	.16
Woody (÷) Jan.	.27 ± .09	126	.26 ± .09	8		
Woody (−) Oct.	−.02 ± .10	27	.05 ± .10	107	.12	.04
Woody (−) Jan.	.03 ± .10	127	.26 ± .09	7		
Woody (+) Oct.	.23 ± .09	29	.29 ± .09	105	.11	.24
Woody (+) Jan.	.19 ± .09	132	−.02 ± .10	2		

The Trabue Sentence Completions Test, when plotted against the other tests, gives the results as shown in Table XVIII.

TABLE XVIII

COEFFICIENTS OF CORRELATION WITH COMPLETIONS TESTS IN GRADE 7 PROGRAM OF TESTS

TIME INTERVAL IN DAYS

$N = 50$

Test	Completions Sept.	Time Interval	Completions Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.28 ± .09	0	.12 ± .09	134	.27	.22
Arith. VI Jan.	.32 ± .09	135	.25 ± .09	1		
Vis. Voc. Sept.	.60 ± .06	0	.52 ± .07	134	.56	.56
Vis. Voc. Jan.	.60 ± .06	133	.52 ± .07	1		
Reading Sept.	.46 ± .08	0	.41 ± .08	134	.50	.46
Reading Jan.	.51 ± .07	134	.54 ± .07	0		
Met. I Sept.	.58 ± .06	0	.58 ± .06	134	.56	.56
Met. I Jan.	.54 ± .07	135	.53 ± .07	1		
Met. III Sept.	.59 ± .06	0	.55 ± .07	134	.56	.59
Met. III Jan.	.63 ± .06	136	.52 ± .07	2		
Ruger Prov. Oct.	.45 ± .08	20	.29 ± .09	114	.42	.38
Ruger Prov. Jan.	.46 ± .08	121	.39 ± .08	13		
Mixed Rel. Oct.	.26 ± .09	20	.49 ± .07	114	.33	.33
Mixed Rel. Jan.	.17 ± .09	121	.40 ± .08	13		
Vis. Voc. XII Oct.	.59 ± .06	21	.54 ± .07	113	.55	.60
Vis. Voc. XII Jan.	.65 ± .06	122	.50 ± .07	12		
Spelling Oct.	.46 ± .07	22	.39 ± .08	112	.40	.40
Spelling Jan.	.40 ± .08	125	.34 ± .08	9		
Courtis (6) Oct.	.29 ± .09	22	.21 ± .09	112	.24	.21
Courtis (6) Jan.	.20 ± .09	125	.18 ± .09	9		
Courtis (8) Oct.	.22 ± .09	23	.18 ± .09	111	.24	.22
Courtis (8) Jan.	.26 ± .09	126	.25 ± .09	8		
Woody (÷) Oct.	.30 ± .09	24	.22 ± .09	110	.30	.22
Woody (÷) Jan.	.22 ± .09	126	.29 ± .09	8		
Woody (−) Oct.	.04 ± .10	27	.05 ± .10	107	.06	.11
Woody (−) Jan.	.16 ± .09	127	.08 ± .09	7		
Woody (+) Oct.	.26 ± .09	29	.25 ± .09	102	.13	.12
Woody (+) Jan.	−.02 ± .10	132	.00 ± .10			

Again the variety in coefficients of correlation between kinds of tasks is large, but the changes due to the time factor are negligible: the average of the fourteen averages for the shorter time interval being .37, for the longer one, .36.

The Metropolitan I Test was a combination of Analogies, Mixed Relations and the like, so called from having been used in testing employees of the Metropolitan Life Insurance Company. The data it yields produce the following coefficients of correlation:

TABLE XIX

COEFFICIENTS OF CORRELATION WITH METROPOLITAN I TESTS IN GRADE 7 PROGRAM OF TESTS

TIME INTERVAL IN DAYS

$N = 50$

Test	Met. I Sept.	Time Interval	Met. I Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.29 ± .09	0	.32 ± .09	135	.37	.38
Arith. VI Jan.	.43 ± .08	135	.44 ± .08	0		
Vis. Voc. Sept.	.40 ± .08	0	.44 ± .08	135	.47	.45
Vis. Voc. Jan.	.45 ± .08	133	.53 ± .07	2		
Reading Sept.	.41 ± .08	0	.44 ± .08	135	.42	.45
Reading Jan.	.46 ± .08	134	.43 ± .08	1		
Completions Sept.	.58 ± .06	0	.54 ± .07	135	.56	.56
Completions Jan.	.58 ± .06	134	.53 ± .07	1		
Met. III Sept.	.66 ± .05	0	.59 ± .06	135	.71	.59
Met. III Jan.	.59 ± .06	136	.75 ± .04	1		
Ruger Prov. Oct.	.49 ± .07	20	.49 ± .07	115	.50	.46
Ruger Prov. Jan.	.32 ± .09	121	.51 ± .07	14		
Mixed Rel. Oct.	.32 ± .09	20	.32 ± .09	115	.44	.46
Mixed Rel. Jan.	.59 ± .06	121	.56 ± .07	14		
Vis. Voc. XII Oct.	.60 ± .06	21	.58 ± .06	114	.50	.54
Vis. Voc. XII Jan.	.49 ± .07	122	.40 ± .08	13		
Spelling Oct.	.42 ± .08	22	.40 ± .08	113	.41	.43
Spelling Jan.	.45 ± .08	125	.40 ± .08	10		
Courtis (6) Oct.	.27 ± .09	22	.29 ± .09	113	.27	.33
Courtis (6) Jan.	.37 ± .08	125	.27 ± .09	10		
Courtis (8) Oct.	.19 ± .09	23	.30 ± .09	112	.26	.26
Courtis (8) Jan.	.22 ± .09	126	.32 ± .09	9		
Woody (÷) Oct.	−.07 ± .09	24	.14 ± .09	111	.07	.21
Woody (÷) Jan.	.28 ± .09	126	.20 ± .09	9		
Woody (−) Oct.	.06 ± .10	27	.08 ± .09	108	.13	.03
Woody (−) Jan.	−.02 ± .10	127	.19 ± .09	8		
Woody (+) Oct.	.19 ± .09	29	.21 ± .09	106	.14	.06
Woody (+) Jan.	−.10 ± .09	132	.09 ± .09	3		

The differences among the average coefficients of correlation range from a reduction of .12 to an increase of .14, which indicates an amount of displacement in achievements of individuals due to their variability for one reason or another greater than any previously encountered. If these fourteen averages be averaged, however, the average for the short time interval becomes .38, for the longer interval, .37.

The Metropolitan III test is again a combination of material used in testing the Metropolitan Life Insurance Company employees. Its correlation coefficients with the data from other tests yield results as shown in Table XX.

TABLE XX

Coefficients of Correlation with Metropolitan III Test
In Grade 7 Program of Tests
Time Interval in Days
$N = 50$

Test	Met. III Sept.	Time Interval	Met. III Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.57 ± .06	0	.47 ± .07	136	.53	.54
Arith. VI Jan.	.61 ± .06	135	.49 ± .07	1		
Vis. Voc. Sept.	.47 ± .07	0	.51 ± .07	136	.59	.57
Vis. Voc. Jan.	.63 ± .06	133	.70 ± .05	3		
Reading Sept.	.41 ± .08	0	.38 ± .08	136	.50	.47
Reading Jan.	.61 ± .06	134	.52 ± .07	2		
Completions Sept.	.59 ± .06	0	.63 ± .06	136	.56	.59
Completions Jan.	.55 ± .07	134	.52 ± .07	2		
Met. I Sept.	.66 ± .05	0	.59 ± .06	136	.71	.59
Met. I Jan.	.59 ± .06	135	.75 ± .04	1		
Ruger Prov. Oct.	.54 ± .07	20	.46 ± .08	116	.51	.41
Ruger Prov. Jan.	.36 ± .08	121	.47 ± .07	15		
Mixed Rel. Oct.	.34 ± .08	20	.35 ± .08	116	.27	.37
Mixed Rel. Jan.	.39 ± .08	121	.20 ± .09	15		
Vis. Voc. XII Oct.	.56 ± .07	21	.54 ± .07	115	.56	.57
Vis. Voc. XII Jan.	.60 ± .06	122	.56 ± .07	14		
Spelling Oct.	.31 ± .09	22	.55 ± .07	114	.41	.44
Spelling Jan.	.32 ± .09	125	.51 ± .07	11		
Courtis (6) Oct.	.50 ± .07	22	.43 ± .08	114	.38	.45
Courtis (6) Jan.	.46 ± .08	125	.26 ± .09	11		

TABLE XX (*Continued*)

Courtis (8) Oct.	.52 ± .07	23	.41 ± .08	113	.47	.44
Courtis (8) Jan.	.47 ± .07	126	.42 ± .08	10		
Woody (÷) Oct.	.15 ± .09	24	.23 ± .09	112	.24	.28
Woody (÷) Jan.	.33 ± .09	126	.32 ± .09	10		
Woody (−) Oct.	.32 ± .09	27	.30 ± .09	109	.35	.26
Woody (−) Jan.	.22 ± .09	127	.38 ± .08	9		
Woody (+) Oct.	.38 ± .08	29	.46 ± .08	107	.26	.25
Woody (+) Jan.	.04 ± .10	132	.14 ± .09	4		

The differences in these average coefficients of correlation range from −.12 to +.10, which in view of the coefficients from which they arise seem fairly important in indicating the variability of the individuals tested; yet since seven of them favor more variability in the results with the short time interval and seven of them contrariwise, the time factor does not seem potent in determining this variability. The average of the fourteen averages is .45 for both the short and the long time interval.

The Ruger Proverbs were written by the pupils on October 4 and January 13, the October 4 date being three weeks (20 days) after the latest previous test. The results which the data therefrom show are given in Table XXI.

The evidence here supports the previous finding. There is variability but not variability which shows any constant trend because of a lapse of time before writing the repeat tests. Four of the averages show gain for the longer period, while nine of them show gain for the shorter period. The average of the fourteen averages is .27 for the shorter time interval, .26 for the longer one.

TABLE XXI

COEFFICIENTS OF CORRELATION WITH RUGER PROVERBS TEST IN GRADE 7 PROGRAM OF TESTS
TIME INTERVAL IN DAYS. $N = 50$

Test	Ruger Prov. Oct.	Time Interval	Ruger Prov. Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.18 ± .09	20	.16 ± .09	121	.24	.29
Arith. VI Jan.	.42 ± .08	115	.29 ± .09	14		
Vis. Voc. Sept.	.35 ± .08	20	.19 ± .09	121	.33	.30
Vis. Voc. Jan.	.41 ± .08	113	.30 ± .09	12		
Reading Sept.	.27 ± .09	20	.27 ± .09	121	.36	.35
Reading Jan.	.43 ± .08	114	.45 ± .08	13		
Completions Sept.	.45 ± .08	20	.46 ± .08	121	.42	.38
Completions Jan.	.29 ± .09	114	.39 ± .08	13		
Met. I Sept.	.49 ± .07	20	.32 ± .09	121	.50	.41
Met. I Jan.	.49 ± .07	115	.51 ± .07	14		
Met. III Sept.	.54 ± .07	20	.36 ± .08	121	.51	.41
Met. III Jan.	.46 ± .08	116	.47 ± .07	15		
Mixed Rel. Oct.	.34 ± .08	0	.32 ± .09	101	.27	.27
Mixed Rel. Jan.	.21 ± .09	101	.20 ± .09	0		
Vis. Voc. XII Oct.	.46 ± .08	1	.31 ± .09	100	.42	.41
Vis. Voc. XII Jan.	.50 ± .07	102	.37 ± .08	1		
Spelling Oct.	.24 ± .09	2	.28 ± .09	99	.23	.27
Spelling Jan.	.25 ± .09	105	.22 ± .09	4		
Courtis (6) Oct.	.23 ± .09	2	.33 ± .09	99	.20	.29
Courtis (6) Jan.	.24 ± .09	105	.17 ± .09	4		
Courtis (8) Oct.	.29 ± .09	3	.34 ± .08	98	.31	.27
Courtis (8) Jan.	.19 ± .09	106	.32 ± .09	5		
Woody (÷) Oct.	−.10 ± .09	4	.15 ± .09	97	.03	.14
Woody (÷) Jan.	.13 ± .09	106	.15 ± .09	5		
Woody (−) Oct.	.02 ± .10	7	.02 ± .10	94	.08	.02
Woody (−) Jan.	.01 ± .10	107	.13 ± .09	6		
Woody (+) Oct.	−.04 ± .10	9	−.03 ± .10	92	−.08	−.15
Woody (+) Jan.	−.28 ± .09	112	−.13 ± .09	11		

The Mixed Relations Test was given October 4 and January 13. Its coefficients of correlation with other tests are shown in Table XXII.

TABLE XXII

COEFFICIENTS OF CORRELATION WITH MIXED RELATIONS TESTS
IN GRADE 7 PROGRAM OF TESTS
TIME INTERVAL IN DAYS. $N = 50$

Test	Mixed Rel. Oct.	Time Interval	Mixed Rel. Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.22 ± .09	20	.13 ± .09	121	.23	.22
Arith. VI Jan.	.30 ± .09	115	.24 ± .09	14		
Vis. Voc. Sept.	.32 ± .09	20	.18 ± .09	121	.30	.28
Vis. Voc. Jan.	.38 ± .08	113	.28 ± .09	12		
Reading Sept.	.13 ± .09	20	.29 ± .09	121	.29	.40
Reading Jan.	.50 ± .07	114	.44 ± .08	13		
Completions Sept.	.26 ± .09	20	.17 ± .09	121	.33	.33
Completions Jan.	.49 ± .07	114	.40 ± .08	13		
Met. I Sept.	.32 ± .09	20	.59 ± .06	121	.44	.46
Met. I Jan.	.32 ± .09	115	.56 ± .07	14		
Met. III Sept.	.34 ± .08	20	.39 ± .08	121	.27	.37
Met. III Jan.	.35 ± .08	116	.20 ± .09	15		
Ruger Prov. Oct.	.34 ± .08	0	.21 ± .09	101	.27	.27
Ruger Prov. Jan.	.32 ± .09	101	.20 ± .09	0		
Vis. Voc. XII Oct.	.38 ± .08	1	.53 ± .07	100	.33	.45
Vis. Voc. XII Jan.	.36 ± .08	102	.28 ± .09	1		
Spelling Oct.	.30 ± .09	2	.29 ± .09	99	.28	.30
Spelling Jan.	.31 ± .09	105	.26 ± .09	4		
Courtis (6) Oct.	.14 ± .09	2	.16 ± .09	99	.28	.24
Courtis (6) Jan.	.32 ± .09	105	.42 ± .08	4		
Courtis (8) Oct.	.25 ± .09	3	.14 ± .09	98	.25	.18
Courtis (8) Jan.	.22 ± .09	106	.24 ± .09	5		
Woody (÷) Oct.	−.03 ± .10	4	−.05 ± .10	97	.06	.09
Woody (÷) Jan.	.23 ± .09	106	.15 ± .09	5		
Woody (−) Oct.	.04 ± .10	7	.01 ± .10	94	.03	.05
Woody (−) Jan.	.09 ± .09	107	.02 ± .10	6		
Woody (+) Oct.	.20 ± .09	9	.13 ± .09	92	.09	.09
Woody (+) Jan.	.04 ± .10	112	−.03 ± .10	11		

The evidence is again confirmatory to the previous findings. Seven of the average coefficients of correlation show a gain over the long time interval while only four of them show a loss. The average of the 14 averages for the short time interval is .25, for the long interval, .27.

On October 5 and on January 14 a different set of Visual Vocabulary material was written. The coefficients of correlation between these tests and the others are as shown in Table XXIII.

TABLE XXIII

COEFFICIENTS OF CORRELATION WITH VISUAL VOCABULARY XII, XIII TESTS IN GRADE 7 PROGRAM OF TESTS
TIME INTERVAL IN DAYS. $N = 50$

Test	Vis. Voc. XII	Time Interval	Vis. Voc. XIII	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.19 ± .09	21	.31 ± .09	122	.23	.28
Arith. VI Jan.	.25 ± .09	114	.27 ± .09	13		
Vis. Voc. Sept.	.61 ± .06	21	.55 ± .07	122	.58	.55
Vis. Voc. Jan.	.54 ± .07	112	.55 ± .07	11		
Reading Sept.	.31 ± .09	21	.40 ± .08	122	.50	.42
Reading Jan.	.43 ± .08	113	.68 ± .05	12		
Completions Sept.	.59 ± .06	21	.65 ± .06	122	.55	.60
Completions Jan.	.54 ± .07	113	.50 ± .07	12		
Met. I Sept.	.60 ± .06	21	.49 ± .07	122	.50	.54
Met. I Jan.	.58 ± .06	114	.40 ± .08	13		
Met. III Sept.	.56 ± .07	21	.60 ± .06	122	.56	.57
Met. III Jan.	.54 ± .07	115	.56 ± .07	14		
Ruger Prov. Oct.	.46 ± .08	1	.50 ± .07	102	.42	.41
Ruger Prov. Jan.	.31 ± .09	100	.37 ± .08	1		
Mixed Rel. Oct.	.38 ± .08	1	.36 ± .08	102	.33	.45
Mixed Rel. Jan.	.53 ± .07	100	.27 ± .09	1		
Spelling Oct.	.44 ± .08	1	.43 ± .08	100	.42	.42
Spelling Jan.	.40 ± .08	104	.39 ± .08	3		
Courtis (6) Oct.	.23 ± .09	11	.42 ± .08	100	.25	.33
Courtis (6) Jan.	.23 ± .09	104	.26 ± .09	3		
Courtis (8) Oct.	.09 ± .09	2	.21 ± .09	99	.13	.17
Courtis (8) Jan.	.12 ± .09	105	.17 ± .09	4		
Woody (÷) Oct.	.15 ± .09	3	.02 ± .10	98	.14	.07
Woody (÷) Jan.	.12 ± .09	105	.13 ± .09	4		
Woody (−) Oct.	−.15 ± .09	6	−.13 ± .09	95	−.07	−.10
Woody (−) Jan.	−.08 ± .09	106	−.00 ± .10	5		
Woody (+) Oct.	.21 ± .09	8	.19 ± .09	93	.00	−.01
Woody (+) Jan.	−.21 ± .09	111	−.21 ± .09	10		

The results here favor the longer time interval as exhibiting less variability in the performance of the subjects than the short interval, the average of the 14 average coefficients being .32 for the shorter interval of time and .34 for the longer interval.

Tests in spelling were written October 6 and January 17. The data therefrom yield the coefficients of correlation as shown in Table XXIV.

TABLE XXIV

Coefficients of Correlation with Spelling Tests
In Grade 7 Program of Tests
Time Interval in Days. $N = 50$

Test	Spell. Oct.	Time Interval	Spell. Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.18 ± .09	22	.16 ± .09	125	.22	.22
Arith. VI Jan.	.28 ± .09	113	.26 ± .09	10		
Vis. Voc. Sept.	.47 ± .07	22	.45 ± .08	125	.50	.50
Vis. Voc. Jan.	.54 ± .07	111	.52 ± .07	8		
Reading Sept.	.21 ± .09	22	.13 ± .09	125	.29	.26
Reading Jan.	.38 ± .08	112	.36 ± .08	9		
Completions Sept.	.46 ± .08	22	.40 ± .08	125	.40	.40
Completions Jan.	.39 ± .08	112	.34 ± .08	9		
Met. I Sept.	.42 ± .08	22	.45 ± .08	125	.41	.43
Met. I Jan.	.40 ± .08	113	.40 ± .08	10		
Met. III Sept.	.31 ± .09	22	.32 ± .09	125	.41	.44
Met. III Jan.	.55 ± .07	114	.51 ± .07	11		
Ruger Prov. Oct.	.24 ± .09	2	.25 ± .09	105	.23	.27
Ruger Prov. Jan.	.28 ± .09	99	.22 ± .09	4		
Mixed Rel. Oct.	.30 ± .09	2	.31 ± .09	105	.28	.30
Mixed Rel. Jan.	.29 ± .09	99	.26 ± .09	4		
Vis. Voc. XII Oct.	.44 ± .08	1	.40 ± .08	104	.42	.42
Vis. Voc. XII Jan.	.43 ± .08	100	.39 ± .08	3		
Courtis (6) Oct.	.05 ± .10	0	.02 ± .10	103	.04	−.01
Courtis (6) Jan.	−.04 ± .10	103	.02 ± .10	0		
Courtis (8) Oct.	.05 ± .10	1	.03 ± .10	102	.05	.08
Courtis (8) Jan.	.12 ± .09	104	.05 ± .10	1		
Woody (÷) Oct.	.19 ± .09	2	.16 ± .09	101	.22	.17
Woody (÷) Jan.	.18 ± .09	104	.24 ± .09	1		

TABLE XXIV (*Continued*)

Woody (−) Oct.	−.11 ± .09	5−	.04 ± .10	98		
Woody (−) Jan.	.02 ± .10	105	.04 ± .10	2	.03	−.01
Woody (+) Oct.	.22 ± .09	7	.21 ± .09	96		
Woody (+) Jan.	.11 ± .09	110	.15 ± .09	7	.19	.16

The evidence again indicates that no importance is to be attached to the time factor. Five of the average coefficients are larger when the time interval is small, and five are larger when the time interval is longer, the average of the 14 averages in each case being .26.

Courtis Arithmetic Tests (called 6) were given October 6 and January 17. The results from these show the coefficients of correlation given in Table XXV with data from other tests.

TABLE XXV

Coefficients of Correlation with Courtis Arithmetic (6) Tests
In Grade 7 Program of Tests
Time Interval in Days. $N = 50$

Test	Courtis (6) Oct.	Time Interval	Courtis (6) Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.48 ± .07	22	.34 ± .08	125	.48	.45
Arith. VI Jan.	.55 ± .07	113	.48 ± .07	10		
Vis. Voc. Sept.	.25 ± .09	22	.18 ± .09	125	.29	.26
Vis. Voc. Jan.	.34 ± .08	111	.32 ± .09	8		
Reading Sept.	.42 ± .08	22	.36 ± .08	125	.51	.50
Reading Jan.	.63 ± .06	112	.59 ± .06	9		
Completions Sept.	.29 ± .09	22	.20 ± .09	125	.24	.21
Completions Jan.	.21 ± .09	112	.18 ± .09	9		
Met. I Sept.	.27 ± .09	22	.37 ± .08	125	.27	.33
Met. I Jan.	.29 ± .09	113	.27 ± .09	10		
Met. III Sept.	.50 ± .07	22	.46 ± .08	125	.38	.45
Met. III Jan.	.43 ± .08	114	.26 ± .09	11		
Ruger Prov. Oct.	.23 ± .09	2	.24 ± .09	105	.20	.29
Ruger Prov. Jan.	.33 ± .09	99	.17 ± .09	4		
Mixed Rel. Oct.	.14 ± .09	2	.32 ± .09	105	.28	.24
Mixed Rel. Jan.	.16 ± .09	99	.42 ± .08	4		
Vis. Voc. XII Oct.	.23 ± .09	1	.23 ± .09	104	.25	.33
Vis. Voc. XII Jan.	.42 ± .08	100	.26 ± .09	3		

TABLE XXV (*Continued*)

Spelling Oct.	.05 ± .10	0	−.04 ± .10	103	.04	−.01
Spelling Jan.	.02 ± .10	103	.02 ± .10	0		
Courtis (8) Oct.	.54 ± .07	1	.60 ± .06	102	.57	.60
Courtis (8) Jan.	.60 ± .06	104	.59 ± .06	1		
Woody (÷) Oct.	.01 ± .10	2	−.06 ± .10	101	.11	.10
Woody (÷) Jan.	.25 ± .09	104	.20 ± .09	1		
Woody (−) Oct.	.19 ± .09	5	.24 ± .09	98	.31	.35
Woody (−) Jan.	.46 ± .08	105	.43 ± .08	2		
Woody (+) Oct.	.33 ± .09	7	.21 ± .09	96	.17	.21
Woody (+) Jan.	.20 ± .09	110	.00 ± .10	7		

The number of excesses in the averages in favor of the short time interval is 7; the number against it is 7. The average of the 14 average coefficients of correlation for the short time interval is .29; for the longer interval it is .31.

A different Courtis Arithmetic Test (called 8) was given October 7 and January 18. The results for it are shown in Table XXVI.

TABLE XXVI

Coefficients of Correlation with Courtis Arithmetic (8) Tests
In Grade 7 Program of Tests
Time Interval in Days. $N = 50$

Test	Courtis (8) Oct.	Time Interval	Courtis (8) Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.54 ± .07	23	.46 ± .08	124	.52	.53
Arith. VI Jan.	.60 ± .06	112	.50 ± .07	9		
Vis. Voc. Sept.	.17 ± .09	23	.16 ± .09	126	.26	.23
Vis. Voc. Jan.	.30 ± .09	110	.34 ± .08	7		
Reading Sept.	.33 ± .09	23	.37 ± .08	126	.42	.43
Reading Jan.	.49 ± .07	111	.51 ± .07	8		
Completions Sept.	.22 ± .09	23	.26 ± .09	126	.24	.22
Completions Jan.	.18 ± .09	111	.25 ± .09	8		
Met. I Sept.	.19 ± .09	23	.22 ± .09	126	.26	.26
Met. I Jan.	.30 ± .09	112	.32 ± .09	9		
Met. III Sept.	.52 ± .07	23	.47 ± .07	126	.47	.44
Met. III Jan.	.41 ± .08	113	.42 ± .08	10		
Ruger Prov. Oct.	.29 ± .09	3	.19 ± .09	106	.31	.27
Ruger Prov. Jan.	.34 ± .08	98	.32 ± .09	5		
Mixed Rel. Oct.	.25 ± .09	3	.22 ± .09	106	.25	.18
Mixed Rel. Jan.	.14 ± .09	98	.24 ± .09	5		

TABLE XXVI (*Continued*)

Vis. Voc. XII Oct.	.09 ± .09	2	.12 ± .09	105	.13	.17
Vis. Voc. XII Jan.	.21 ± .09	99	.17 ± .09	4		
Spelling Oct.	.05 ± .10	1	.12 ± .09	104	.05	.08
Spelling Jan.	.03 ± .10	102	.05 ± .10	1		
Courtis (6) Oct.	.54 ± .07	1	.60 ± .06	104	.57	.60
Courtis (6) Jan.	.60 ± .06	102	.59 ± .06	1		
Woody (÷) Oct.	.24 ± .09	1	.09 ± .09	102	.21	.17
Woody (÷) Jan.	.25 ± .09	103	.18 ± .09	0		
Woody (−) Oct.	.47 ± .07	4	.35 ± .08	99	.51	.43
Woody (−) Jan.	.50 ± .07	104	.54 ± .07	1		
Woody (+) Oct.	.38 ± .08	6	.24 ± .09	97	.29	.26
Woody (+) Jan.	.27 ± .09	109	.19 ± .09	6		

In this series five of the coefficients of correlation show decrease for the short time interval, while eight of them show increase. The average of the 14 averages for the short time interval is .32; for the longer interval, .31.

The Woody Arithmetic test in division was given on October 8 and on January 18. Its coefficients of correlation with other tests are given in Table XXVII.

TABLE XXVII

Coefficients of Correlation with Woody Division Tests
In Grade 7 Program of Tests
Time Interval in Days. $N = 50$

Test	Woody (÷) Oct.	Time Interval	Woody (÷) Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.19 ± .09	24	.15 ± .09	126	.23	.03
Arith. VI Jan.	−.09 ± .09	111	.26 ± .09	9		
Vis. Voc. Sept.	.20 ± .09	24	.10 ± .09	126	.23	.20
Vis. Voc. Jan.	.29 ± .09	109	.25 ± .09	7		
Reading Sept.	.09 ± .09	24	.27 ± .09	126	.18	.16
Reading Jan.	.05 ± .10	110	.26 ± .09	8		
Completions Sept.	.30 ± .09	24	.22 ± .09	126	.30	.22
Completions Jan.	.22 ± .09	110	.29 ± .09	8		
Met. I Sept.	−.07 ± .09	24	.28 ± .09	126	.07	.21
Met. I Jan.	.14 ± .09	111	.20 ± .09	9		
Met. III Sept.	.15 ± .09	24	.33 ± .09	126	.24	.28
Met. III Jan.	.23 ± .09	112	.32 ± .09	10		

TABLE XXVII (*Continued*)

Ruger Prov. Oct.	−.10 ± .09	4	. ± .09	106	.03	.14
Ruger Prov. Jan.	.15 ± .09	97	.15 ± .09	5		
Mixed Rel. Oct.	−.03 ± .10	4	.23 ± .09	106	.06	.09
Mixed Rel. Jan.	−.05 ± .10	97	.15 ± .09	5		
Vis. Voc. XII Oct.	.15 ± .09	3	.12 ± .09	105	.14	.07
Vis. Voc. XII Jan.	.02 ± .10	98	.13 ± .09	4		
Spelling Oct.	.19 ± .09	2	.18 ± .09	104	.22	.17
Spelling Jan.	.16 ± .09	101	.24 ± .09	1		
Courtis (6) Oct.	.01 ± .10	2	.25 ± .09	104	.11	.10
Courtis (6) Jan.	−.06 ± .10	101	.20 ± .09	1		
Courtis (8) Oct.	.24 ± .09	1	.25 ± .09	103	.21	.17
Courtis (8) Jan.	.09 ± .09	102	.18 ± .09	0		
Woody (−) Oct.	.33 ± .09	3	.31 ± .09	99	.42	.35
Woody (−) Jan.	.38 ± .08	103	.51 ± .07	1		
Woody (+) Oct.	.34 ± .08	5	.38 ± .08	97	.30	.36
Woody (+) Jan.	.34 ± .08	108	.26 ± .09	6		

The differences in the average coefficients of correlation range from −.20 to +.11, there being five which are larger over the longer time interval and nine that are larger over the shorter time interval. The average of the 14 averages is .20 for the shorter interval, .18 for the longer.

TABLE XXVIII

Coefficients of Correlation with Woody Subtraction Tests In Grade 7 Program of Tests Time Interval in Days. $N = 50$

Test	Woody (−) Oct.	Time Interval	Woody (−) Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.47 ± .07	27	.41 ± .08	127	.40	.39
Arith. VI Jan.	.37 ± .08	108	.33 ± .09	8		
Vis. Voc. Sept.	−.20 ± .09	27	.05 ± .10	127	.05	.06
Vis. Voc. Jan.	.06 ± .10	106	.29 ± .09	6		
Reading Sept.	−.02 ± .10	27	.03 ± .10	127	.12	.04
Reading Jan.	.05 ± .10	107	.26 ± .09	7		
Completions Sept.	.04 ± .10	27	.16 ± .09	127	.06	.11
Completions Jan.	.05 ± .10	107	.08 ± .09	7		
Met. I Sept.	.06 ± .10	27	−.02 ± .10	127	.13	.03
Met. I Jan.	.08 ± .10	108	.19 ± .09	8		

TABLE XXVIII (*Continued*)

Met. III Sept.	.33 ± .09	27	.22 ± .09	127	.36	.26
Met. III Jan.	.30 ± .09	109	.38 ± .08	9		
Ruger Prov. Oct.	.02 ± .10	7	.01 ± .10	107	.08	.02
Ruger Prov. Jan.	.02 ± .10	94	.13 ± .09	6		
Mixed Rel. Oct.	.04 ± .10	7	.09 ± .09	107	.03	.05
Mixed Rel. Jan.	.01 ± .10	94	.02 ± .10	6		
Vis. Voc. XII Oct.	−.15 ± .09	6	−.08 ± .09	106	−.07	−.10
Vis. Voc. XII Jan.	−.13 ± .09	95	−.00 ± .10	5		
Spelling Oct.	−.11 ± .09	5	.02 ± .10	105	−.03	−.01
Spelling Jan.	−.04 ± .10	98	.04 ± .10	2		
Courtis (6) Oct.	.19 ± .09	5	.46 ± .08	105	.31	.35
Courtis (6) Jan.	.24 ± .09	98	.43 ± .08	2		
Courtis (8) Oct.	.47 ± .07	4	.50 ± .07	104	.51	.43
Courtis (8) Jan.	.35 ± .08	99	.54 ± .07	1		
Woody (÷) Oct.	.33 ± .09	3	.38 ± .08	103	.42	.35
Woody (÷) Jan.	.31 ± .09	99	.51 ± .07	1		
Woody (+) Oct.	.33 ± .09	2	.30 ± .09	98	.33	.27
Woody (+) Jan.	.23 ± .09	105	.32 ± .09	5		

On October 11 and January 19 the Woody Subtraction test was written by these 50 pupils. The results when plotted against the data from other tests are given in Table XXVIII.

This test shows the greatest effect of time in decreasing the coefficient of correlation that has yet been dealt with in the data from these fifty seventh grade pupils. Nine of the average coefficients are reduced for the longer period of time as compared with the shorter, while five are increased. The average of the 14 averages is .19 for the shorter period, .16 for the longer.

The Woody Addition test was written by these pupils on October 13 and again on January 24. The coefficients of correlation between the data from it and those from the other tests are given in Table XXIX.

In this group of data, three of the coefficients are larger over the longer time interval, while ten of them are smaller; the average of the 14 average coefficients is .17 for the shorter time interval, .16 for the longer.

The evidence *in toto* from the battery of tests given to the fifty pupils in Grade 7, P. S. No. 51, is decisive in its conclusions.

TABLE XXIX

COEFFICIENTS OF CORRELATION WITH WOODY ADDITION TESTS
IN GRADE 7 PROGRAM OF TESTS
TIME INTERVAL IN DAYS. $N = 50$

Test	Woody (+) Oct.	Time Interval	Woody (+) Jan.	Time Interval	Av. Short Time	Av. 4 Months' Interval
Arith. VI Sept.	.44 ± .08	29	.15 ± .09	132	.29	.22
Arith. VI Jan.	.29 ± .09	106	.14 ± .09	3		
Vis. Voc. Sept.	.18 ± .09	29	.09 ± .09	132	.20	.16
Vis. Voc. Jan.	.22 ± .09	104	.21 ± .09	1		
Reading Sept.	.23 ± .09	29	.19 ± .09	132	.11	.24
Reading Jan.	.29 ± .09	105	−.02 ± .10	2		
Completions Sept.	.26 ± .09	29	−.02 ± .10	132	.13	.12
Completions Jan.	.25 ± .09	105	−.00 ± .10	2		
Met. I Sept.	.19 ± .09	29	−.10 ± .09	132	.14	.06
Met. I Jan.	.21 ± .09	106	.09 ± .09	3		
Met. III Sept.	.38 ± .08	29	.04 ± .10	132	.26	.25
Met. III Jan.	.46 ± .08	107	.14 ± .09	4		
Ruger Prov. Oct.	−.04 ± .10	9	−.28 ± .09	112	−.08	−.15
Ruger Prov. Jan.	−.03 ± .10	92	−.13 ± .09	11		
Mixed Rel. Oct.	.20 ± .09	9	.04 ± .10	112	.09	.09
Mixed Rel. Jan.	.13 ± .09	92	−.03 ± .10	11		
Vis. Voc. XII Oct.	.21 ± .09	8	−.21 ± .09	111	.00	−.01
Vis. Voc. XII Jan.	.19 ± .09	93	−.21 ± .09	10		
Spelling Oct.	.22 ± .09	7	.11 ± .09	110	.19	.16
Spelling Jan.	.21 ± .09	96	.15 ± .09	7		
Courtis (6) Oct.	.33 ± .09	7	.20 ± .09	110	.17	.21
Courtis (6) Jan.	.21 ± .09	96	.00 ± .10	7		
Courtis (8) Oct.	.38 ± .08	6	.27 ± .09	109	.29	.26
Courtis (8) Jan.	.24 ± .09	97	.19 ± .09	6		
Woody (÷) Oct.	.34 ± .08	5	.34 ± .08	108	.30	.36
Woody (÷) Jan.	.38 ± .08	97	.26 ± .09	6		
Woody (−) Oct.	.33 ± .09	2	.23 ± .09	105	.33	.27
Woody (−) Jan.	.30 ± .09	98	.32 ± .09	5		

These children had been subjected to various types of experimentation, with various environmental factors planned to discover the effect upon their learning. At times wise motivation had secured excellent coöperation from them, but at times

boredom with tests was operative in them. A period of approximately one half of a school year had permitted normal growth. The low coefficients of correlation among many of the tests are an indication of the variety of conditions, materials, and subjective factors.

The time interval called shorter ranges from that called zero, where the tests were written on the same day, to 29 days; the interval called longer ranges from 92 days to 136 days. The earliest tests in the first series were written September 14 and the latest October 13. The earliest tests in the second series were written January 13, the latest ones January 28. There is thus considerable variation in the time intervals for which difference in the coefficients of correlation is sought. None the less there is no consistent trend to either an increase or a decrease in these coefficients with a short or long interval of time elapsing between tests. Of the fifteen sets of coefficients of correlation listed in the preceding pages, two show the same final average, five are lowered 1 point in the second decimal place, three are lowered 2 points, and one is lowered 3 points; while one is raised 1 point and three are raised 2 points, all in the second decimal place.

TESTS IN HANDWRITING

The same pupils who were tested in the experiment whose results have been treated in the preceding pages also were tested in handwriting. The results for this testing are reported separately from the preceding elaborate series, since a somewhat different procedure was used. The handwriting tests were written on these dates: October 14, forenoon and afternoon; November 1, forenoon and afternoon; November 3; November 12; November 15, forenoon and afternoon; January 21, forenoon and afternoon. The coefficients of correlation for tests written in the forenoon and afternoon of the same day are:

Oct. 14	.77	Nov. 15	.84
Nov. 1	.80	Jan. 21	.57

The average of these four coefficients is .74½.

The coefficient for the tests Nov. 3 *vs.* Nov. 12, when but one test was written each day, was .74.

The various coefficients of inter-correlation are given in Table XXX.

The figures under "Time Interval" indicate the number of days elapsing between tests. There is evidence here of decreasing coefficients as the time interval increases, though the coefficient of self-correlation of the January 21 data as compared with those for the earlier dates gives evidence of some variability factor other than time. The average of the coefficients of correlation of tests written the same day is .75; of the four for tests written 2 or 3 days apart, .74; of the 9 for tests written one and two weeks apart (9 to 14 days), .65; of the 6 for tests written between two and three weeks apart, (17 to 19 days) .59; of the 6 for tests written between four and five weeks apart (28 to 32 days), .48; of the 16 for tests written about 10 to 14 weeks apart (67 to 99 days), .48. The effect of the time interval as a factor seems no more potent for tests written two or three days apart than for those written on the forenoon and afternoon of the same day, and such effect as time may have is exhausted after the lapse of about a month.

TABLE XXX

Coefficients of Inter-Correlation in Handwriting Tests In Grade 7, Program of Tests. Time Interval in Days. $N = 50$

	A.M. Oct. 14	P.M. Oct. 14	Time Interval	A.M. Nov. 1	P.M. Nov. 1	Time Interval	Nov. 3	Nov. 12	Time Interval	A.M. Nov. 15	P.M. Nov. 15	Time Interval
Nov. 1	.59±.06	.59±.06										
Nov. 1	.72±.05	.62±.06	17									
Nov. 3	.53±.07	.46±.08	19	.68±.05	.64±.06	2						
Nov. 12	.57±.06	.44±.08	28	.61±.06	.64±.06	11						
Nov. 15	.51±.07	.42±.08		.67±.05	.62±.06		.68±.05	.83±.03	12, 3			
Nov. 15	.55±.07	.40±.08	32	.62±.06	.65±.06	14	.65±.06	.79±.04	12, 3			
Jan. 21	.29±.09	.24±.09		.54±.07	.36±.08		.60±.06	.51±.07	79, 70	.52±.07	.64±.06	
Jan. 21	.36±.08	.35±.08	99	.53±.07	.45±.08	81	.54±.07	.64±.06	79, 70	.54±.07	.53±.07	67

The effect of time of day for such tests is apparently negligible. The average of the 6 coefficients where forenoon is plotted against forenoon is .52; of the 6 for afternoon against afternoon, .50; of the 12 for forenoon against afternoon, excluding those written the same day, .52. If the four coefficients of correlation for tests written in the forenoon and afternoon of the same day are included, the last figure becomes .57.

CHAPTER V

THE DATA AND THEIR TREATMENT (*Concluded*)

TESTS IN COLOR NAMING

During the experimentation carried on at Teachers College for the New York State Commission on Ventilation many tests were administered to squads of adults.[1] Two groups of these data have been chosen to use in this study since they offer a type of mental work of a less complex intellectual nature, depending more upon acuity of vision and less upon the so-called higher thought processes. These are color naming and cancellation of 2's and 3's. Squads of four college students, nineteen [2] individuals in all, identified the color of small squares whose tints were arranged in a random order, only primary colors being used. The score is in terms of the number of seconds required to name correctly the colors of one hundred squares. Two periods of work subdivided into an early and late division were performed each day for five successive days. The periods for the mental tests were from 2:30 to 3:45 and from 4:15 to 5:30, these periods being used for color naming, cancelling 2's, cancelling 3's, naming 50 opposites, a two-minute column addition test, and a twenty-minute mental multiplication test.

The coefficients of self-correlation of the two parts of each of the ten work periods in color naming are:

1st Day	Early	.88 ± .03
	Late	.93 ± .02
2nd Day	Early	.87 ± .04
	Late	.88 ± .03
3rd Day	Early	.76 ± .07
	Late	.91 ± .03
4th Day	Early	.84 ± .05
	Late	.91 ± .03
5th Day	Early	.86 ± .04
	Late	.91 ± .03

It is worth while to note that in every case the two halves of

[1] E. L. Thorndike, W. A. McCall, and J. C. Chapman. *Ventilation in Relation to Mental Work*, 1916.

[2] The twentieth individual was unable to complete all the tests.

the late period are more highly correlated than the two halves of the early period. The variability in performance is thus evidently dependent on some factor other than time, since the time interval between halves is the same in the early and the late periods. The average coefficients for the five days are in order: .91, .88, .84, .88, .89, a curiously near-symmetric form.

The four coefficients of inter-correlation for each day of the series between the halves of the early and late periods are:

		Early I	Early II
Day 1	Late I	.97 ± .01	.93 ± .02
	Late II	.90 ± .03	.93 ± .02
Day 2	Late I	.90 ± .03	.87 ± .04
	Late II	.89 ± .03	.84 ± .05
Day 3	Late I	.89 ± .03	.88 ± .03
	Late II	.89 ± .03	.78 ± .06
Day 4	Late I	.84 ± .05	.91 ± .03
	Late II	.79 ± .06	.96 ± .01
Day 5	Late I	.76 ± .07	.92 ± .02
	Late II	.74 ± .07	.86 ± .04

The time interval between an Early I and Late II or an Early II and Late II is about 2 hours; between a Late I and Early II about 1½ hours; between an Early I and Late II about 2½ hours. With these small time differences the coefficients range from .74 to .97. The average of the 10 coefficients whose time limit is about 2 hours (Early I and Late I, and Early II and Late II) is .87; that of the 5 coefficients of about 1½ hours' time interval (Late I *vs.* Early II) is .90; that of the 5 coefficients of about 2½ hours' time interval (Early I *vs.* Late II) is .84. This amount of difference in coefficients is as great as that found over half-year periods in the data from 50 children in Grade 7. The average of the four coefficients for each day may be compared with the coefficients of self-correlation which are reported on page 41. They are for days 1 to 5, in order .94, .88, .86, .88, .82. These range from .82 to .94, the previously reported ones from .84 to .91. The average of the 20 coefficients representing the same day's work is .87.

To consider the effect of the twenty-four hour interval plus or minus the testing period for a day, the following coefficients are offered:

TABLE XXXI

COEFFICIENTS OF INTER-CORRELATION WITH 24 HOURS' TIME INTERVAL VENTILATION DATA. COLOR NAMING. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.86 ± .04	.86 ± .04	.88 ± .03	.85 ± .04
Day 1	Early II	.82 ± .05	.88 ± .03	.84 ± .05	.81 ± .05
vs.	Late I	.90 ± .03	.86 ± .04	.87 ± .04	.84 ± .05
Day 2	Late II	.81 ± .05	.87 ± .04	.85 ± .04	.85 ± .04
	Early I	.86 ± .04	.91 ± .03	.84 ± .05	.83 ± .05
Day 2	Early II	.92 ± .02	.84 ± .05	.80 ± .06	.81 ± .05
vs.	Late I	.94 ± .02	.90 ± .03	.91 ± .03	.91 ± .03
Day 3	Late II	.88 ± .03	.86 ± .04	.82 ± .05	.92 ± .02
	Early I	.72 ± .07	.75 ± .07	.77 ± .06	.84 ± .05
Day 3	Early II	.89 ± .03	.87 ± .04	.93 ± .02	.90 ± .03
vs.	Late I	.80 ± .06	.83 ± .05	.88 ± .03	.80 ± .06
Day 4	Late II	.88 ± .03	.89 ± .03	.95 ± .02	.89 ± .03
	Early I	.73 ± .07	.87 ± .04	.81 ± .05	.88 ± .03
Day 4	Early II	.76 ± .07	.93 ± .02	.84 ± .05	.91 ± .03
vs.	Late I	.72 ± .07	.88 ± .03	.88 ± .03	.90 ± .03
Day 5	Late II	.69 ± .08	.84 ± .05	.81 ± .05	.86 ± .04

If this group of 64 coefficients be sorted by time intervals and those with equal intervals be averaged, the results are as follows: The average of the 4 coefficients representing the shortest time interval, approximately 21 hours (Late II of one day with Early I of the next day), is .85; the average of the 8 with an approximately 21½ hours interval (Late I of one day with Early I of the next and Late II of one day with Early II of the next) is .84; the 4 with approximately 22 hours' interval (Late I of one day with Early II of the next) is .85; the 8 with approximately 23 hours' interval (Early II of one day with Early I of the next and Late II of one day with Late I of the next) is .85½; the average of the 16 with exactly a 24 hours' interval (Early I *vs.* Early I, Late I *vs.* Late I, Early II *vs.* Early II and Late II *vs.* Late II) is .86; the average of the 8 with about 24½ hours' interval (Early I of one day *vs.* Early II of the next and Late I of one day *vs.* Late II of the next) is .85; the average of the 4 with about 25 hours' time (Early II of one day *vs.* Late I of the next day) is .87; the average of the 8 with about 26 hours' time interval (Early I of one day with Late I of the next day, and Early II of one day with Late II of the next day) is .85; the average of the 4 with nearly 27 hours' time interval is .81½. There seems to be no consistent change with increasing

time, the averages for the periods ranging from 21 to 27 hours, approximately being in order .85, .84, .85, .85½, .86, .85, .87, .85, .81½. The average for the 64 coefficients covering 24 hours plus or minus the testing period is .85, .02 less than the average for the 20 coefficients representing the same day's work.

The coefficients of correlation for a two-day time interval plus or minus the testing period are given in Table XXXII.

TABLE XXXII

COEFFICIENTS OF INTER-CORRELATION WITH 48 HOURS' TIME INTERVAL VENTILATION DATA. COLOR NAMING. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.88 ± .03	.92 ± .02	.90 ± .03	.89 ± .03
Day 1	Early II	.67 ± .09	.82 ± .05	.73 ± .07	.73 ± .07
vs.	Late I	.85 ± .04	.91 ± .03	.88 ± .03	.85 ± .04
Day 3	Late II	.80 ± .06	.87 ± .04	.82 ± .05	.79 ± .06
	Early I	.76 ± .07	.75 ± .07	.84 ± .05	.88 ± .03
Day 2	Early II	.88 ± .03	.91 ± .03	.90 ± .03	.89 ± .03
vs.	Late I	.84 ± .05	.84 ± .05	.94 ± .02	.84 ± .05
Day 4	Late II	.88 ± .03	.90 ± .03	.87 ± .04	.97 ± .01
	Early I	.89 ± .03	.78 ± .06	.87 ± .04	.81 ± .05
Day 3	Early II	.89 ± .03	.82 ± .05	.87 ± .04	.84 ± .05
vs.	Late I	.78 ± .06	.85 ± .04	.82 ± .05	.74 ± .07
Day 5	Late II	.80 ± .06	.72 ± .07	.81 ± .05	.77 ± .06

The average of the 18 coefficients with less than 48 hours' time interval is .83½; the average of the 12 with 48 hours' time interval is .85; the average of the 18 with more than 48 hours' interval is .83; the average for the 48 coefficients covering the two-day period is .84, .01 less than the average of the 64 coefficients relating to work on successive days.

TABLE XXXIII

COEFFICIENTS OF INTER-CORRELATION WITH 72 HOURS' TIME INTERVAL VENTILATION DATA. COLOR NAMING. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.67 ± .09	.72 ± .07	.70 ± .08	.72 ± .07
Day 1	Early II	.90 ± .03	.91 ± .03	.86 ± .04	.87 ± .04
vs.	Late I	.87 ± .04	.83 ± .05	.86 ± .04	.82 ± .05
Day 4	Late II	.82 ± .05	.90 ± .03	.85 ± .04	.86 ± .04
	Early I	.80 ± .06	.80 ± .06	.82 ± .05	.86 ± .04
Day 2	Early II	.79 ± .06	.81 ± .05	.81 ± .05	.82 ± .05
vs.	Late I	.69 ± .08	.74 ± .07	.78 ± .06	.70 ± .08
Day 5	Late II	.64 ± .09	.78 ± .06	.73 ± .07	.73 ± .07

The two groups of coefficients of correlation for a three-day interval plus or minus the testing period are given in Table XXXIII.

The average of the 12 coefficients with less than 72 hours' interval is .79; of the 8 coefficients with 72 hours' interval, .80; of the 12 coefficients with more than 72 hours' interval, .80. The average of the 32 coefficients of approximately 3 days' interval is .80.

There remains the group of 16 coefficients of correlation covering a four-day interval plus or minus the testing period. They are given in Table XXXIV.

TABLE XXXIV

COEFFICIENTS OF INTER-CORRELATION WITH 96 HOURS' TIME INTERVAL VENTILATION DATA. COLOR NAMING. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.83 ± .05	.86 ± .04	.87 ± .04	.91 ± .03
Day 1	Early II	.82 ± .04	.90 ± .03	.89 ± .03	.88 ± .03
vs.	Late I	.76 ± .07	.81 ± .04	.79 ± .06	.79 ± .06
Day 5	Late II	.67 ± .09	.76 ± .07	.72 ± .07	.71 ± .08

The average of the 6 coefficients with less than 96 hours' interval is .87; of the four with 96 hours' interval, .81; of the six with more than 96 hours' interval, .76. The average of the 16 coefficients with approximately 4 days' interval is .81.

If the same, one, two, three, four days' averages be considered, it is noted that they are, in order: .87, .85, .84, .80, .81. The difference found here is less than that found between the one hour and the two and one half hours marking the shortest and longest intervals for the four divisions of the same day.

TESTS IN CANCELLATION

Another group of tests undergone by these same nineteen young men at the same sittings in which the color naming was done involved cancellation of 2's and 3's from a printed page of figures. As was done in the color naming experiment, the scores were reported in two sub-divisions of the Early and Late periods of work. In the Early period 2's were cancelled for 60 seconds, in the late period 3's were cancelled for the same length of time. In arriving at the score, a penalty was imposed when the proper figure was left uncancelled and when wrong figures were cancelled,

and the final score was in terms of 2 times the number properly cancelled after the penalties were deducted.

The coefficients of self-correlation of the two parts of the 10 work periods are:

Day I	2's	.83 ± .05
	3's	.70 ± .08
Day II	2's	.90 ± .03
	3's	.65 ± .09
Day III	2's	.89 ± .03
	3's	.85 ± .04
Day IV	2's	.91 ± .03
	3's	.80 ± .06
Day V	2's	.87 ± .04
	3's	.88 ± .03

It is notable how much greater is the coefficient for cancelling 2's than 3's, the average in the former case being .88, in the latter, .78.

The four coefficients of inter-correlation for each day of the series between the Early and Late divisions are:

		Early I	Early II
Day 1	Late I	.75 ± .07	.78 ± .06
	Late II	.72 ± .07	.84 ± .05
Day 2	Late I	.70 ± .08	.82 ± .05
	Late II	.75 ± .07	.83 ± .05
Day 3	Late I	.87 ± .04	.79 ± .06
	Late II	.86 ± .04	.92 ± .02
Day 4	Late I	.88 ± .03	.86 ± .04
	Late II	.90 ± .03	.90 ± .03
Day 5	Late I	.82 ± .05	.93 ± .02
	Late II	.72 ± .07	.90 ± .03

The time interval covered per day by these divisions ranges from about 1½ to 2½ hours. The coefficients range from .70 to .90. The average of the five coefficients with a time interval of about 1½ hours is .84; of the 10 with a time interval of about 2 hours, .84; of the 5 with a time interval of about 2½ hours, .79. The difference here in favor of the shorter interval is approxi-

mately the same as in the color naming results. The average of the 20 coefficients which represent the same day's work is .83. The average of the four coefficients for each day may be compared with the self-correlations reported on page 48. They are in order: .77, .78, .86, .89, and .84, and parallel closely the previously reported ones.

The 24 hours' interval plus or minus the testing period yields data from which the following coefficients are found:

TABLE XXXV

Coefficients of Inter-Correlation with 24 Hours' Time Interval Ventilation Data. Cancellation. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.84 ± .05	.84 ± .05	.76 ± .07	.80 ± .06
Day 1	Early II	.81 ± .05	.86 ± .04	.79 ± .06	.83 ± .05
vs.	Late I	.60 ± .10	.75 ± .07	.67 ± .09	.63 ± .09
Day 2	Late II	.63 ± .09	.82 ± .05	.66 ± .09	.78 ± .06
	Early I	.78 ± .06	.82 ± .05	.75 ± .07	.75 ± .07
Day 2	Early II	.86 ± .04	.87 ± .04	.79 ± .06	.84 ± .05
vs.	Late I	.68 ± .08	.66 ± .09	.66 ± .09	.71 ± .08
Day 3	Late II	.74 ± .07	.88 ± .03	.80 ± .06	.84 ± .05
	Early I	.86 ± .04	.88 ± .03	.80 ± .06	.90 ± .03
Day 3	Early II	.84 ± .05	.91 ± .03	.79 ± .06	.94 ± .02
vs.	Late I	.83 ± .05	.87 ± .04	.67 ± .09	.82 ± .05
Day 4	Late II	.81 ± .05	.87 ± .04	.75 ± .07	.93 ± .02
	Early I	.79 ± .06	.86 ± .04	.82 ± .05	.84 ± .05
Day 4	Early II	.86 ± .04	.93 ± .02	.87 ± .04	.87 ± .04
vs.	Late I	.91 ± .03	.92 ± .02	.89 ± .03	.85 ± .04
Day 5	Late II	.86 ± .04	.92 ± .02	.81 ± .05	.87 ± .04

The average of the 4 coefficients with the shortest time interval, approximately 21 hours, is .82; the average for the 8 coefficients with time interval of about 21½ hours is .83; the average of the four with about 22½ hours' interval is .81; the average of the 8 with an interval of about 23½ hours is .80; the average of the 16 with 24 hours' interval is .82; the average of the 8 with about 24½ hours' interval is .80; the average of the 8 with about 26 hours' interval is .81; the average of the 4 with about 27 hours' interval is .84, or, in order by time intervals increasing from 21 to 27 hours, .82, .83, .81, .80, .82, .80, .81, 84. The average for the 64 coefficients having a span of 24 hours plus or minus the testing period is .81. Comparison of this figure with that of the

average of the 20 coefficients relating to the same day's work reveals a reduction of .02 in the average.

The coefficients of correlation found when an interval of 48 hours plus or minus the testing period has occurred are given in Table XXXVI.

TABLE XXXVI

COEFFICIENTS OF INTER-CORRELATION WITH 48 HOURS' TIME INTERVAL VENTILATION DATA. CANCELLATION. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.73 ± .07	.84 ± .05	.83 ± .05	.86 ± .04
Day 1	Early II	.74 ± .07	.78 ± .06	.77 ± .06	.78 ± .06
vs.	Late I	.67 ± .09	.82 ± .05	.85 ± .04	.73 ± .07
Day 3	Late II	.66 ± .09	.88 ± .03	.80 ± .06	.78 ± .06
	Early I	.75 ± .07	.79 ± .06	.78 ± .06	.78 ± .06
Day 2	Early II	.82 ± .05	.84 ± .05	.75 ± .07	.86 ± .04
vs.	Late I	.76 ± .07	.82 ± .05	.80 ± .06	.76 ± .07
Day 4	Late II	.70 ± .08	.81 ± .05	.80 ± .06	.85 ± .04
	Early I	.78 ± .06	.85 ± .04	.69 ± .08	.83 ± .05
Day 3	Early II	.79 ± .06	.91 ± .03	.66 ± .09	.87 ± .04
vs.	Late I	.79 ± .06	.87 ± .04	.70 ± .08	.84 ± .05
Day 5	Late II	.75 ± .07	.81 ± .05	.71 ± .08	.86 ± .04

If these 48 coefficients be divided into the groups of 3, 6, 3, 6, 12, 6, 3, 6, 3 coefficients which correspond to varying time intervals from 45 to 51 hours, the results show the following averages: .82, .80, .73, .80, .80, .78, .84, .79, .70. The average of the 48 coefficients representing the two days' interval more or less is .79. This figure is a reduction of .04 from the figure for the same day's work and of .02 from that for the 24 hours' interval.

The 32 coefficients for the interval of 72 hours plus or minus the testing period are given in Table XXXVII.

TABLE XXXVII

COEFFICIENTS OF INTER-CORRELATION WITH 72 HOURS' TIME INTERVAL VENTILATION DATA. CANCELLATION. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.61 ± .10	.83 ± .05	.76 ± .07	.69 ± .08
Day 1	Early II	.63 ± .09	.86 ± .04	.83 ± .05	.76 ± .07
vs.	Late I	.64 ± .09	.83 ± .05	.70 ± .08	.73 ± .07
Day 4	Late II	.59 ± .10	.84 ± .05	.70 ± .08	.76 ± .07
	Early I	.80 ± .06	.83 ± .05	.74 ± .07	.81 ± .05
Day 2	Early II	.88 ± .03	.90 ± .03	.78 ± .06	.91 ± .03
vs.	Late I	.81 ± .05	.82 ± .05	.67 ± .09	.85 ± .04
Day 5	Late II	.74 ± .07	.78 ± .06	.71 ± .08	.88 ± .03

Grouping these by the time intervals from 69 to 75 hours into groups containing 2, 4, 2, 4, 8, 4, 2, 4, 2 coefficients, the following averages are found: .75, .79, .81, .81, .77, .73, .83, .77, .67. The average for the 32 coefficients is .77 which figure shows a reduction of .02 from the average for the 48 hours' interval, .04 from the average for the 24 hours' interval, and .06 from the average for the same day.

The 16 coefficients showing a 96 hours' interval plus or minus the testing period are given in Table XXXVIII.

TABLE XXXVIII

COEFFICIENTS OF INTER-CORRELATION WITH 96 HOURS' TIME INTERVAL VENTILATION DATA. CANCELLATION. $N = 19$

		Early I	Early II	Late I	Late II
	Early I	.74 ± .07	.81 ± .05	.76 ± .07	.68 ± .08
Day 1	Early II	.65 ± .09	.85 ± .04	.73 ± .07	.76 ± .07
vs.	Late I	.60 ± .10	.82 ± .05	.69 ± .08	.75 ± .07
Day 5	Late II	.51 ± .11	.88 ± .03	.73 ± .07	.78 ± .06

Grouping these by the time interval of from 93 to 99 hours into 1, 2, 1, 2, 4, 2, 1, 2, 1 coefficients, their averages are in order .68, .76, .73, .78, .77, .69, .82, .74, .51. The average for the 16 coefficients representing approximately 96 hours' time interval is .73, which is a reduction of .04 from that shown with the 72 hours' interval.

The general trend of the data from the experiment in cancelling numbers verifies that found in color naming. Generally speaking, the factors which produce variability are active largely in independence of the time element, though there is evident a gradual diminution in the coefficients of correlation with the lapse of greater time intervals.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The material utilized in this study has an enormous range as judged from several aspects. The ages of subjects have ranged from nine- or ten-year-old children to middle-aged adults. The intelligence maturity has ranged from the fourth grade public school level to that of college students and adults not in college. The types of tests have varied from highly intellectual material such as is found in the harder parts of the Selective and Relational Thinking, Generalization and Organization, and in the reading and completion tasks in the Thorndike Intelligence Examination for High School Graduates, to operations of such negligible mental effort as naming primary colors or crossing out 2's from a page of printed ciphers. The mere list of tests used is impressive: Army Alpha (Tests 2, 4, 5, 6, 7), Thorndike Intelligence Examination for High School Graduates (a 3-hour test), I. E. R. Tests of Selective and Relational Thinking, Generalization and Organization (a 2-hour test), a battery of Completions, Arithmetic, Non-Verbal, Analogies, Reading, College Entrance Tests, and the like (a 9-hour test); Vocabulary Tests; another battery of Arithmetic Problems, Vocabulary, Reading, Completions, Associations, Selections, Mixed Relations, Analogies, Spelling, Proverbs, Arithmetic Computation and the like; Handwriting Tests; Color Naming; Cancellation of Figures. The length of time that any individual was tested varies from a few minutes (5 to 20 in the initial Thorndike Test of Word Knowledge and $6\frac{3}{4}$ minutes in the Army Alpha) to 9 hours of work in one day unrelieved except for luncheon and short rest periods (in the first test with 20 adults). The repetitions of the test program varied from one rewriting, as in the nine-hour program, to doing five forms of Army Alpha each twice, or naming colors and cancelling 2's or 3's four times per day for 5 consecutive days. The time interval covered by such testing programs ranged from a single day, through successive days, a week, ten days, a month, three months, four months, a year. The number of individuals involved in any

experiment varies from 19 in the case of color naming and cancellation, through 20, 30 (14 and 16), 50, 170, 205, 500 (250 and 250), to 668 (35, 58, 166, 190, and 219) in the case of the Word Knowledge Tests. The geographical location where the testing was done includes every section of the United States except the south: New York City; Trenton, New Jersey; Iowa City, Iowa; Kansas City, Missouri; Denver, Colorado; Palo Alto, California, and other cities between these. The time of year at which testing was done includes every season. External conditions included all types of surroundings. Atmospheric conditions in the case of the experiments with 50 children in Grade 7 and 19 adults in color naming and cancellation were artificially controlled to offer great variety. In fact, the only general selective factor operative in all cases that can be definitely postulated is that the individuals were all in such trim of physical and mental fitness as made it possible for them to be examined at all. None were confined to bed by illness and none were confined to institutions because of mental deficiency. Otherwise no constant selective factor is known to operate in the data.

In view of this wide divergence in source material, the consonance of the results is the more striking and turns what might seem upon less substantial grounds to be a chance or probability conclusion to practical certainty.

The conclusions, most of which had already been accepted by common sense, are:

1. Individuals are variable in the amount and quality of mental work they can produce under a specified set of conditions. This statement does not mean merely that individuals differ from each other, but that the performance of a single individual is a variable quantity.[1]

2. This variability of individuals' performance may be of such magnitude as to change a coefficient of correlation from .60 to .91 in the case of cancellation during the first half of an early period one day and the first half of a late period one day later; or from .67 to .87 in an hour's work in arithmetic against an hour's work in completions when written on the same day, the two sittings being 7 days apart; or from .49 to .69 when an easy reading test

[1] Recently made and as yet unpublished studies in the Institute of Educational Research at Teachers College have accumulated data on the amount of variability of an individual under conditions of training and of lack of training. These data are of great significance in the entire problem of measuring the variability of an individual.

is plotted against a mixed relations test a week later, or *vice versa*; or from .46 to .63 when arithmetic problems and completions are written in forenoon and afternoon, the harder half of one test and the easier half of the other being interchanged in the meantime; or even from −.20 to +.29 when the Woody subtraction test is plotted against a vocabulary test.

3. The lapse of time between tests is one factor in the variability of an individual's performance. This factor, however, is of small importance in estimating the total variability of an individual. The progressive variability with increasing lapse of time is very slight if it truly exists at all. Very little more difference can be found after a year than after a week, and little more after some days than after some hours.

4. The effect of a time interval is somewhat more uncertain upon children than upon adults, the results for the children in Grades 4 to 8 in tests of word knowledge showing lessening variability among older children, while in the numerous tests upon seventh grade pupils, of the 15 sets of data shown, 9 show results favoring decreased coefficients of correlation with a time interval, 4 show increased coefficients, and 2 show no change.

The practical implications of these results are:

1. In determining how variable any individual may be, the time element may be disregarded or given very small weight. He is as likely to be different after a few minutes as after days or weeks.

2. In determining the reliability of a testing instrument, the time element is of small consequence. The repeat test may be given the same day, several days later, a year later, with but small difference in the results. This statement does not mean to assert that there is no practice effect from retaking a test. In much of the material here considered, the practice effect had been disposed of by earlier trials on the tests.[2]

Further investigation upon the variability of the individual is needed to establish the true causes of such changeableness. Since the amount of variability is largely independent of the level of ability, and [3] since a lapse of time seems to increase the variability

[2] Thorndike in *The Measurement of Intelligence* (now in press) argues, from data collected and analyzed by him, for replacing the coefficient of unreliability of a test by the probable error of the measurement.

[3] See Thorndike, *The Measurement of Intelligence*, now in press.

but little, the utilization of a unit of measure in intelligence testing based upon variability is a practical possibility.

Later investigation may well consider the effect upon the variability of an individual of fatigue, distracting surroundings, motivation, and the like. To accomplish such an investigation, experiments in most cases would need to be set up specifically. It would not be possible to utilize such heterogeneous data as that considered in this study. For that reason the conclusions would need verification by several repetitions of the experiment with controlled procedure upon non-homogeneous and non-similar groups.

BIBLIOGRAPHY

Brown, William. *Essentials of Mental Measurement.* Cambridge University Press, 1911.

Hollingworth, H. L. "Correlations of Achievement Within an Individual." *Journal of Experimental Psychology,* 8:190–208, June, 1925.

Kelley, T. L. *Statistical Method.* Macmillan, 1923.

McCall, W. A. *How to Measure in Education.* Macmillan, 1922.

McCall, W. A. *Correlation of Some Psychological and Educational Measurements.* Teachers College, Columbia University, Contributions to Education, No. 79, 1916.

New York State Commission on Ventilation. Report. 1915.

Ruch, G. M. "Correlations of Initial and Final Capacities in Learning." *Journal of Experimental Psychology,* 6:344–56, October, 1923.

Spearman, C. "Coefficient of Correlation Calculated from Faulty Data." *British Journal of Psychology,* 3:271–95, October, 1910.

Stenquist, J. L. "Unreliability of Individual Scores in Mental Measurements." *Journal of Educational Research,* 4:347–54, December, 1921.

Symonds, P. M. "A Study of Extreme Cases of Unreliability." *Journal of Educational Psychology,* 15:99–106, February, 1924.

Thorndike, E. L. "The Variability of an Individual in Repetitions of the Same Task." *Journal of Experimental Psychology,* 6:161–67, April, 1923.

Thorndike, E. L. *The Measurement of Intelligence.* Teachers College, Columbia University, Bureau of Publications. (Now in press.)

Thorndike, E. L., McCall, W. A., and Chapman, J. C. *Ventilation in Relation to Mental Work.* Teachers College, Columbia University, Contributions to Education, No. 78, 1916.

Thorndike, E. L., Ruger, G. J., and McCall, W. A. "The Effects of Outside Air and Re-circulated Air upon Intellectual Achievement and Improvement." *School and Society,* 3:679–84, May, 1916.

VITA

Ella Woodyard was born June 1, 1878, in Labette County, Kansas. She received schooling in the local public district school, being graduated from the Labette County Schools in 1891. She entered high school at Baldwin, Kansas, in 1892, and was graduated in 1895. In 1899 she received the degree of Bachelor of Arts from Baker University, and in 1900 the degree of Bachelor of Pedagogy from the same institution. She taught mathematics in the high school in Kansas City, Kansas, from 1900 to 1919. In February, 1920, Columbia University granted her the degree of Master of Arts.

Since June 1, 1921, she has been Assistant in the Institute of Educational Research, Division of Educational Psychology, Teachers College, Columbia University, New York.